THE JOURNAL

of

THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS

MAY 1912

35 CENTS A COPY $3 A YEAR

SPRING MEETING: CLEVELAND, OHIO, MAY 28-31
MONTHLY MEETINGS: NEW YORK, MAY 14
BOSTON, MAY 17

HAVE YOU RESPONDED?

Membership in The American Society of Mechanical Engineers, *the society of the industries*, is esteemed and its value appreciated by everyone who has been the recipient of its many privileges. Nevertheless it is a fact that the value of such membership would be materially enhanced by the coöperation within the Society of many engineers who have never had the aims and purposes of the Society presented to them.

We are certain that if our members fully appreciated this they would make every effort to enlist the interest of eligible non-members. It is only by such activity on the part of *every member* that the Society can render its highest service to the country, the profession and the individual. After all, the benefit which each member derives from the Society is proportional to the amount of energy which he contributes to it.

Will you not enlist your services to the end that the aims and privileges of the Society may be brought to the attention of all who are entitled to participate in them? The Committee is hopeful that you will respond promptly and assist them in securing for the Society the membership of the leading men in every industry.

COMMITTEE ON INCREASE OF MEMBERSHIP

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OF
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COMING MEETINGS OF THE SOCIETY

April 30, *New York City*, Engineering Societies Building, 8.15 p.m. Conferring of Honorary Membership on Rudolph Diesel, inventor of the Diesel Engine. Illustrated address, under the auspices of the Gas Power Section, on The Development of the Diesel Engine.

May 14, *New York City*, Engineering Societies Building, 8.15 p.m. Paper: Commercial Dictating Machines, A. J. McFaul. Discussion by representative leading makers on the market.

May 16, *Boston, Mass.* Papers: Progress in Development of a New Type of Centrifugal Pump and Blower, especially for Steam Turbine Drive, C. V. Kerr and A. L. Schaller; Increase of Bore of High-Speed Wheels by Centrifugal Stresses, Sanford A. Moss.

May 28–31, *Cleveland, Ohio.* Spring Meeting. The program appears on another page.

Announcement: Papers for the next Annual Meeting should be in hand September 1. See page 13.

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THE SPRING MEETING

The program for the Spring Meeting at Cleveland is published herewith, and although subject to change is substantially in the form in which the professional sessions and the entertainment of the members and their friends will be carried out. It should be noted especially that the date of the meeting is May 28–31 instead of during the first week in June as first announced. The attractiveness of Cleveland as a city and its location on the lake, together with its remarkable industrial development, all contribute to make it one of the most interesting places for a meeting of engineers. The generous hospitality which its residents have shown on many occasions is known to all and the efforts which the local membership are putting forth to insure that the time of every visiting member shall be fully and pleasantly occupied may well lead to great anticipations on the part of those expecting to attend. The arrangements for the reception of the visitors are in the hands of an Executive Committee of which Past-President Ambrose Swasey is Chairman; Professor Robert H. Fernald, Vice-Chairman; F. W. Ballard, Secretary and R. B. Sheridan, Treasurer. It requires but a glance at the program to show how profitable and enjoyable an occasion this Committee and the Committee on Meetings of the Society have arranged.

TENTATIVE PROGRAM

TUESDAY, MAY 28

Registration at headquarters, Chamber of Commerce Hall, after 10 a.m.

Informal reception at the home of Mr. and Mrs. Ambrose Swasey, 7808 Euclid Ave., from 4 to 6 p.m.

Membership reunion and informal evening, Chamber of Commerce Hall, 8.30 p.m.

WEDNESDAY, MAY 29

Business Meeting, 10 a.m., Chamber of Commerce Hall
Professional Session, 10.30 a.m., Chamber of Commerce Hall

A New Analysis of the Cylinder Performance of Reciprocating Engines, J. Paul Clayton

Equipment of a Modern Flour Mill on a Gradual Reduction System, John F. Harrison and W. W. Nichols

Design and Mechanical Features of the California Gold Dredge, Robert E. Cranston (To be read by title, discussion invited)

Simultaneous Session, Gas Power Section, 10.30 a.m., Chamber of Commerce Library

Problems in Natural Gas Engineering, Thomas R. Weymouth

Other papers to be announced.

Entertainment

Special Inspection Trip for ladies to plant of H. Black Company, cloak manufacturers, 10 a.m.

Lunch at Chamber of Commerce Hall, 12.30 p.m.

Inspection of local manufacturing and power plants, 2 p.m.

Automobile trip for ladies through the parks, 2 p.m.

Tea at Country Club, for members and guests, 4 to 6 p.m.

Lecture, Chamber of Commerce Hall, 8.30 p.m.

Sound Waves, How to Photograph Them and What They Mean, Dr. Dayton C. Miller, Case School of Applied Science

The lecture will be illustrated with apparatus and experiments and especially with the new instrument, the "Phonodeik," for projecting sound waves directly upon the screen.

THURSDAY, MAY 30

Professional Session, Chamber of Commerce Hall, 10 a.m.

New Processes for Chilling Cast Iron, Thos. D. West

Strength of Steel Tubes, Pipes and Cylinders under Internal Fluid Pressure, Reid T. Stewart

On the Control of Surges in Water Conduits, W. F. Durand

Speed Regulation in Hydro-Electric Plants, Wm. F. Uhl (To be read by title, discussion invited)

Entertainment

Excursion on Lake Erie, 1 to 5 p.m.

Reception and dance at Colonial Club, 8.30 p.m.

FRIDAY, MAY 31

Professional Session, 10 a.m., Chamber of Commerce Hall

The Present State of Development of Large Steam Turbines, A. G. Christie

A Discussion of Certain Thermal Properties of Steam, G. A. Goodenough

The Reduction in Temperature of Condensing Water Reservoirs due to Cooling Effect of Air and Evaporation, W. B. Ruggles

Results of Tests on the Discharge Capacity of Safety Valves, E. F. Miller and A. B. Carhart (To be read by title, discussion invited)

Entertainment

Lunch at Chamber of Commerce Hall, 12 o'clock sharp.

Excursion to Akron, leaving Chamber of Commerce, 12.30 p.m.

Inspection of plant of The Goodrich Rubber Company.

Inspection of plant of Wellman-Seaver-Morgan Company.

Inspection of plant of Diamond Match Company at Barberton.

Ladies are invited to make the trip to Akron.

RAILROAD TRANSPORTATION NOTICE

Every effort has been made to secure reduced rates on the certificate plan for members and guests in attendance at the Spring Meeting, but the widespread adoption of the two-cent rate and similar restrictions have operated to make this impossible.

All the railroads will provide special cars or special trains if the advance reservations warrant such service. Members are therefore urged to secure tickets and Pullman reservations a day or two in advance, in all cases stating that accommodations are desired on The American Society of Mechanical Engineers' special.

TRAIN SCHEDULES[1]

New York Central Lines

Lv. New York	5.30 p.m.	6.30 p.m.	8.02 p.m.
Lv. Boston	2.00	2.00	4.50 p.m.
Lv. Worcester	3.12	3.12	6.00 p.m.
Lv. Providence			4.10 p.m.
Lv. Albany	8.15	9.55	11.45 p.m.
Arr. Cleveland	7.15 a.m.	7.30 a.m.	10.47 a.m.
Fare New York to Cleveland	$14	$15	$13

Pennsylvania

Lv. New York	5.04 p.m.	6.32 p.m.		8.30 p.m.
Lv. North Philadelphia	7.02 p.m.	8.17 p.m		
Lv. Philadelphia				10.48 p.m.
Lv. Washington			6.45 p.m.	
Lv. Baltimore			7.52 p.m.	
Lv. Harrisburg	9.39 p.m.	10.34 p.m.	10.17 p.m.	1.20 a.m.
Arr. Cleveland	7.30 a.m.	7.30 a.m.	7.30 a.m.	11.30 a.m.

Lackawanna-Nickel Plate

Lv. New York	6.30 p.m.
Lv. Scranton	11.28 p.m.
Arr. Cleveland	11.19 a.m.
Fare New York to Cleveland	$12

PULLMAN RESERVATIONS

Pullman rates on all roads are: Lower berth, $3; upper berth, $2.40; drawing room, $11. The Society cannot undertake to arrange transportation matters for members. Tickets and Pullman reservations may be obtained at any ticket office or by mail from the following: New York Central Lines: New York, Mr. W. V. Lifsey, G. E. P. A., Broadway and 30th St.; Boston, Mr. C. E. Colony, C. P. A., Boston & Albany R.R.; Pennsylvania: New York, Mr.C. Studds, D. P. A., 263 Fifth Ave.; Philadelphia, Mr. R. L. Stall, D. P. A., 1433 Chestnut St.; Baltimore, Mr. Hugh Hasson, D. P. A., Baltimore and Calvert Sts.; Washington, Mr. B. M. Newbold, D. P. A., 15th and G Sts.; Lackawanna-Nickel Plate: NewYork, Mr. A. W. Ecclestone, D. P. A., Nickel Plate Road, 385 Broadway.

[1] Subject to change.

HOTEL RATES FOR SPRING MEETING AT CLEVELAND

	Without Bath			With Bath		
	Single Room	Single Room, Two Persons	Double Room, Two Persons	Single Room	Single Room, Two Persons	Double Room Two Persons
Hollenden Hotel......	$2.00	$3.00	$3.50	$2.50 to 4.00	$4.00 to 5.00	$5.00 to 7.00
The Colonial.........	2.00	.....	.....	2.50 to 5.00	.....	.....
Hotel Euclid.........	1.50	.....	.....	2.00 to 5.00	.....	.....

GERMAN MUSEUM COMMISSION

MEETING IN NEW YORK, APRIL 9.

At a meeting in New York on April 9, the greetings of the Society were extended to the members of the German Museum Commission, now on a visit to America to study important engineering achievements. The Commission, which is headed by Dr. Oscar von Miller, member of the House of Lords of Bavaria and President of the Verein deutscher Ingenieure, includes a number of prominent scientific men, His Excellency Dr. Count von Podewils-Durniz, former Secretary of State of Bavaria; Dr. W. von Borscht, Lord Mayor of Munich and Privy Councillor; Dr. W. von Dyck, Privy Councillor, Rector Emeritus of the Technical University of Munich; Herr Ph. Gelius, Architect of the Museum; Herr Alex. Schirmann, Director of the Library of the Museum; Dr. Fuchs, Professor of Physics and Mathematics; Engineer Fr. Orth, Mining Engineer, Director of Sections of the Museum; Engineer Kurt Trautwein, Civil Engineer, Director of Divisions of the Museum; and Dr. Colin Ross, Secretary of the Commission.

Dr. Alex. C. Humphreys, President of the Society, presided and spoke of the splendid work of the Museum for science. The speaker of the evening, Dr. Von Miller, was then introduced, and his address read by Charles Whiting Baker.

The purpose for which the German Museum was built, he said, was to show by actual samples and models the development of the natural and technical sciences, in an instructive and attractive form. In this way the layman receives concise and impressive instruction in all important departments of natural science and technology, while the numerous historical originals give the expert an opportunity for research in the domain of his art.

The great inventions are presented in the Museum by a series of constructions, from the first crude designs, through the successive stages of development to the most recently perfected devices, thus showing how each new construction depends upon former achievements, and how these again become the point of departure for

further advancement and improvement. Whenever possible, this is done by the original apparatus used or constructed by the inventor himself. When the original apparatus could not be obtained, reproductions were made for the Museum; thus in the case of the "Old Puffing Billy," of which the original is in the South Kensington Museum, a reproduction was made, so exact in the smallest details even to rust spots, that the photographs of the original and of the reproduction cannot be distinguished from each other.

When an object cannot be exhibited in the original on account of its dimensions, plans and models are included in the Museum collections. Thus the development of the human dwelling, from the prehistoric cave to the modern skyscraper, is shown by a long series of models, arranged so that relative importance is prominently brought out by contrasting different building systems.

The most valuable and beautiful originals would, however, often remain unintelligible to laymen if they were not explained more fully. The sectional models are the first step in this system of technical education. Some of the models are only sectionally cut and uncovered, in order to explain to the observer the interior arrangement, while in others ways are devised to show also the particular action on which the machine is based. For example, in Alban's tubular boiler the way in which water and steam move and the gases of combustion return are illustrated by arrow marks, while in a Krupp converter the rising air bubbles are painted on glass. Some of the originals are supplemented by working models showing the mode of operation of the machines. Such working models are used not only in the machine section, but also in the natural science departments, where every visitor can in this way perform some of the experiments for himself. There is, for example, an apparatus for demonstrating the properties of liquid air. Five vessels filled with it can be moved up and down in a cabinet to dip substances in it, experimentally, and the visitor can see for himself how mercury freezes in liquid air, rubber loses its elasticity, carbon dioxide gas becomes solid, and the electric resistance of a supply wire of an electric lamp falls off. In an X-ray cabinet a switch is moved by opening the door; the cabinet is darkened, and the switching in of the X-ray tubes follows automatically, and a screen of chloride of barium is illuminated so that an object selected by the observer, himself, such as his hand or purse, can be seen illuminated by the X-rays. After two minutes the X-ray tubes are switched off and the cabinet automatically lighted again.

Whenever necessary, descriptions, drawings and concise explanation of processes are placed at the beginning of many groups or above particular exhibits. Statistical tables and tabulated statements are also included to show the influence of science and technic on human culture and economic life, the relations of production and consumption, market conditions, etc.

The main objects of the Museum, illustration and instruction, are accomplished in the best and most attractive manner possible, considerable stress being laid on the artistic point of view. Each object is, as far as possible, presented in a proper setting, in a room adapted to it. Thus various old blacksmith's tools have found a place in an old smith's shop; the chemical apparatus and vessels used at different epochs are exhibited in a series of laboratories, from the quaint laboratory of the alchemist and phlogistian to the familiar types of today.

The needs of the expert as well as the layman are fully cared for also. A library connected with the Museum embraces the entire literature of natural science and technology of the present day, as well as numerous historical and rare works, and letters of celebrated men of science. An extensive collection of plans affords to the engineer and architect an opportunity to acquaint himself with the way in which others solved the questions which interest him.

A Hall of Fame serves to commemorate great investigators and technicians, whose names should be as familiar to the public as those of great statesmen and generals.

A new home is now being built for the Museum which will provide about 350,000 sq. ft. of space for exhibition purposes, not including the large library, reading rooms, lecture rooms and meeting halls. There will also be special facilities for experimental work, such as a tower 230 feet high for geodetical and meteorological observations, and a station for wireless telegraphy and telephony.

Following the reading of this paper, Dr. von Miller thanked the Society in his native tongue for the assistance rendered the Commission and expressed the hope that should the American people build a similar museum they would come over to Germany and learn how not to repeat some of their mistakes.

Dr. W. von Dyck then spoke of the publication of biographies and documents of science and technic which the Museum is planning, and presented to the President of the Society the first volume of the series, written by himself, containing the biography of Georg von

Reichenbach, an engineer and astronomer, who lived at the time when Watt was engaged in laying the foundations of modern engineering. This was accepted by Dr. Humphreys and has been placed in the Library of the Society.

A reception in the rooms of the Society followed the meeting, in which all were given an opportunity to greet the Commissioners personally.

VISIT TO PHILADELPHIA

A committee of the Society greeted the Commission upon their arrival in Philadelphia on April 11 and assisted them in their inspection of various interesting points during their two days' visit. Representatives of the Committee, which consisted of A. C. Jackson, Chairman, D. R. Yarnall, Charles Day, Morris L. Cooke, T. C. McBride, S. L. Kneass, James M. Dodge, W. C. Kerr, S. S. Webster, Coleman Sellers, Jr., and J. E. Gibson, met the Commissioners at the train and escorted them to the office of the Mayor, who received them most cordially. During the morning the City planning exhibit in the City Hall, Wanamaker's store, and the Girard Trust Company were inspected and luncheon was served at the Engineers Club. The Baldwin Locomotive Works, the new William Penn High School, and the Boys' Central High School occupied the remainder of the day. On Friday, April 12, trips were made to the University of Pennsylvania, where the new engineering building and the university museum proved especially interesting; the School of Industrial Art, Franklin Institute, Memorial Hall in Fairmount Park, and the J. G. Johnson Art Gallery. The Mayor entertained the Commission at luncheon on Friday in the Union League Club.

ITINERARY

The itinerary of the Commission as planned includes Washington, Pittsburgh, Chicago, Niagara Falls and Buffalo, Schenectady, Boston, and a return visit to New York, where they will sail for Europe on April 30. Committees of the Society have been formed at each of these points to greet the Commission and to assist them in making the tours of inspection which they desire. Gen. William H. Bixby acted as chairman of the reception committee in Washington, George M. Brill, Vice-President, in Chicago, C. H. Bierbaum in Buffalo, H. G. Reist in Schenectady, and Prof. I. N. Hollis in Boston.

GENERAL NOTES

MEETINGS IN HONOR OF DR. DIESEL

Dr. Rudolph Diesel, inventor of the Diesel engine and director of the Verein deutscher Ingenieure, is expected to be in New York on April 30, at which time Honorary Membership will be conferred upon him by the Society at a meeting in the auditorium of the Engineering Societies Building. Dr. Diesel is widely known to engineers and the public at large through the fame of his invention, and members of sister societies have been invited to participate in this meeting in his honor. Following the conferring of Honorary Membership, Dr. Diesel will give an illustrated address, under the auspices of the Gas Power Section of the Society, on the Development of the Diesel Engine.

On April 13 Dr. Diesel made a brief address upon the same subject before a large audience in St. Louis, and during his stay in that city was tendered a dinner at the Mercantile Club by the Associated Engineering Societies. On April 17 he visited Cornell University, making a similar address, and on April 26 spoke at the United States Naval Academy at Annapolis upon the Relation of the Gas Engine to the Propulsion of Vessels. His complete and more carefully prepared address upon the Diesel Engine will be made at the larger gathering in New York.

MEASUREMENT OF TAPS, BOLTS AND SCREWS

As a result of interest awakened in the subject of the measurement of taps, bolts and screws at the March meeting in New York, it has been suggested by the chairman of the Committee on Meetings in New York that the Society should appoint a committee to make recommendations for standard methods of measurement. It is probable that comparatively few users of these articles have definite knowledge of the degree of accuracy which they are securing when purchasing, and few even have suitable measuring instruments for screw threads. Much delay is occasioned in assembling work through the lack of proper methods and instruments for measuring the screws

and taps that are to be used. It has further been suggested that the scope of the committee might be extended to include the standardization of limits for other machine parts as well; for it is only by such standardization in any manufacturing plant that interchangeability can be attained and the cost of assembling brought within a reasonable figure, not to mention the possibility of duplicating work on subsequent orders.

PATENT CONFERENCE AT WASHINGTON

Upon invitation of the Patent Law Association, an informal conference has been held in Washington, April 15 and 16, to discuss the situation resulting from several bills now pending in Congress relating to proposed changes in the patent laws. Several of the national societies participated and to represent The American Society of Mechanical Engineers the Council appointed as Honorary Vice-Presidents, W. H. Blauvelt, consulting engineer of the Semet-Solvay Company, Syracuse, N. Y.; B. F. Wood, assistant engineer of the motive power department, Pennsylvania Railroad Company, Altoona, Pa.; and J. B. F. Herreshoff, president and treasurer of the Herreshoff Manufacturing Company, Bristol, R. I.

In appointing these representatives, the Society believed that so many of the membership had large interests at stake in the patent system that it should be ably represented in any conference relating to the matter of patent law, and that the Society at large should take some part in an affair affecting so important a feature of national development.

TESTIMONIAL FROM STEVENS ALUMNI TO DR. DENTON

Dr. James E. Denton, a charter member of the Society and one of its managers from 1889–1892, now emeritus professor of engineering practice of Stevens Institute of Technology, was recently honored by the alumni of that college. Dr. Denton, who is himself a graduate of Stevens, had long been associated with its faculty, but was recently obliged by impaired health to retire from active work. As a tribute to the mechanical genius and strong personality of Dr. Denton, a handsome watch and fob, accompanied by a beautifully engraved testimonial, bearing the signatures of a majority of the alumni and instructors of the college, were presented.

IMPORTANT ANNOUNCEMENT REGARDING ANNUAL MEETING

The Committee on Meetings announce that the Society has reached the point where in the future it will be necessary for papers to be

submitted earlier than has heretofore been the custom, in order to secure consideration for any given meeting. In order to avoid disappointment on the part of those expecting to contribute, papers for the next Annual Meeting in December should be in the hands of the Secretary of the Society by September 1. The responses to the efforts of the Committee in securing papers of high engineering merit have been generous, and it is felt that the greatest good to all will be realized by allowing ample time for the advance publication of papers and the solicitation of discussion. The committee is making this early announcement so that there will be ample time to prepare manuscript by the date mentioned.

THE PRESENT STATE OF DEVELOPMENT OF LARGE STEAM TURBINES

By A. G. Christie

ABSTRACT OF PAPER

This paper deals with the present state of development of leading types of large steam turbines, some details of construction, the commercial results obtained and some new uses to which steam turbines have been put. It also points out the probable tendencies of steam-turbine development.

For the purposes of discussion, large steam turbines are divided into two types, fundamental and modified or combined. The weak elements of the fundamental types are discussed and the advantages of the new types pointed out. Some new constructons are shown in section.

The details of construction are discussed fully. A table with brief notes on the details of construction of individual types is included for rapid comparison of the practice of various manufacturers. The different types are also compared on the basis of efficiency as shown by published results of tests.

The present status of low-pressure turbines, turbo-compressors, turbo-driven pumps, geared turbines and marine turbines is discussed briefly. The closing paragraphs deal with the probable trend of steam turbine development and future possibilities.

THE PRESENT STATE OF DEVELOPMENT OF LARGE STEAM TURBINES

By A. G. Christie, Madison, Wis.

Associate Member of the Society

The Transactions of the Society for 1910 includes two papers on steam turbines, which, with the accompanying discussions, give interesting information on the present development of two prominent American types. Mr. Geo. A. Orrok discussed small steam turbines in his paper published in Vol. 31 of the Transactions. Vol. 25 contains papers and discussions presented at the Chicago meeting of the Society in 1904, which cover the leading types of steam turbines then in commercial use. It seems fitting now to record the present state of development of large steam turbine construction and of the field of the steam turbine both in this country and in Europe.

PRESENT FIELD OF LARGE STEAM TURBINES

2 Steam turbines are now being used for driving alternating-current generators, turbo-compressors, turbo-blowers, pumps and marine propellers, and, by means of gearing, to furnish power to direct-current generators, rolling mills and the propeller shafts of steamships. Reciprocating engines were formerly used for such purposes, but recently this class of engine has seldom been installed except for rolling-mill work, non-condensing service as on heating systems, rope and belt drives, hoists, and in certain combinations with low-pressure turbines in marine work. The high economy of the piston-pumping engines and also of some types of air compressors, has continued their popularity in spite of the increasing competition of steam turbine units. The steam turbine has found favor principally on account of its low first cost of installation, its small

The American Society of Mechanical Engineers, 29 West 39th Street, New York. All papers are subject to revision.

floor space requirements, its continued good steam economy over a period of years and its small operating and repair charges.

3 The increased use of steam turbines in sizes up to 1000 h. p. seems to have received at least a temporary check in Europe by the introduction of the new Stumpf direct-flow engine.

TYPES OF STEAM TURBINES

4 For the purpose of this paper, large commerical steam turbines will be divided into two classes: (*a*) fundamental types, and (*b*) modified or combined types.

5 The fundamental types of turbines are as follows:

a The Parsons type, which works on the so-called "reaction" principle. In this type the heat energy of the steam is changed into kinetic energy, both in the stationary guide blades and in the moving blades. In other words, both sets of blades act as orifices expanding the steam through a small pressure drop. As nozzles and orifices usually have very high efficiencies, this turbine should, theoretically, prove the most economical of all types. The construction of the Parsons turbine is familiar to all engineers. It consists of a drum, or a number of drums, carrying the blade rows which alternate with rows in the casing. The drums carry balance pistons to equalize the end thrust.

b The Curtis type, which works on the impulse principle with high steam velocities and few stages. Each stage, however, is provided with two or more rows of revolving blades known as "velocity rows," with intermediate rows of guide blades. The steam velocity at the beginning of each stage is high. The characteristics of this type of turbine are presented in Mr. W. L. R. Emmet's paper, The Steam Turbine in Modern Engineering.[1] The revolving blades are carried on disks separated by diaphragms, which extend to the shaft and which carry the orifices between stages. Curtis turbines are now usually built with horizontal shafts. In American practice some sizes over 7000 kw. still have vertical shafts.

c The Rateau turbine, which consists of a number of simple impulse wheels in series on the same shaft and separated from one another by diaphragms carrying nozzles. It

[1] Trans. Am. Soc. M. E., vol. 25, p. 1041.

operates with lower steam velocities than the Curtis and consequently has many more stages. Each revolving element carries only one row of blades. The characteristics of this type will be found in Prof. A. Rateau's paper, Different Applications of Steam Turbines.[1]

The type of turbine known as the Zoelly belongs to the same classification as the Rateau, from which it differs only in the use of higher steam velocities, in the number of stages and in certain constructional details. Fig. 1 shows a section of a Zoelly turbine. Though this type has been widely adopted abroad, it has not been placed on the American market up to the present time.

6 Each of these fundamental types is based on sound theoretical principles. In the process of manufacture and in operation, certain features have not proved entirely satisfactory, hence far-reaching modifications have been made in the design of some types of turbines. Some manufacturers have combined the characteristics of two or more types to overcome the inherent limitations of each fundamental type. A discussion of the unsatisfactory operating conditions of each type will show the reasons which led up to the changes in recent turbines and will also aid in distinguishing the novel features of new designs.

7 The first rows of spindle blades in a standard Parsons turbine are placed on a drum of small diameter in order to make the blades as long as possible and to minimize the proportional leakage losses past the ends of the blades. A large number of rows are provided in order to keep the steam velocities low, as the blade velocities must be low with the small drum. The drop in pressure at each row is small and hence the leakage is correspondingly reduced. This construction results in a turbine with a long spindle and with great distance between bearings. High-pressure steam, frequently at high temperature, is admitted to the casing. Distortion of casing and spindle are thus easily conceivable in such construction, and to allow for this contingency the clearance on the ends of all blades is usually increased. This distortion may be due either to unequal heating or to the growth of the cast-iron casings. The fluid friction losses are large in this high-pressure section, for a large number of rows of blades must be revolved in steam of high density. The leakage losses and fluid friction losses in the high-pressure section, to-

[1] Trans. Am. Soc. M. E., vol. 25, p. 782.

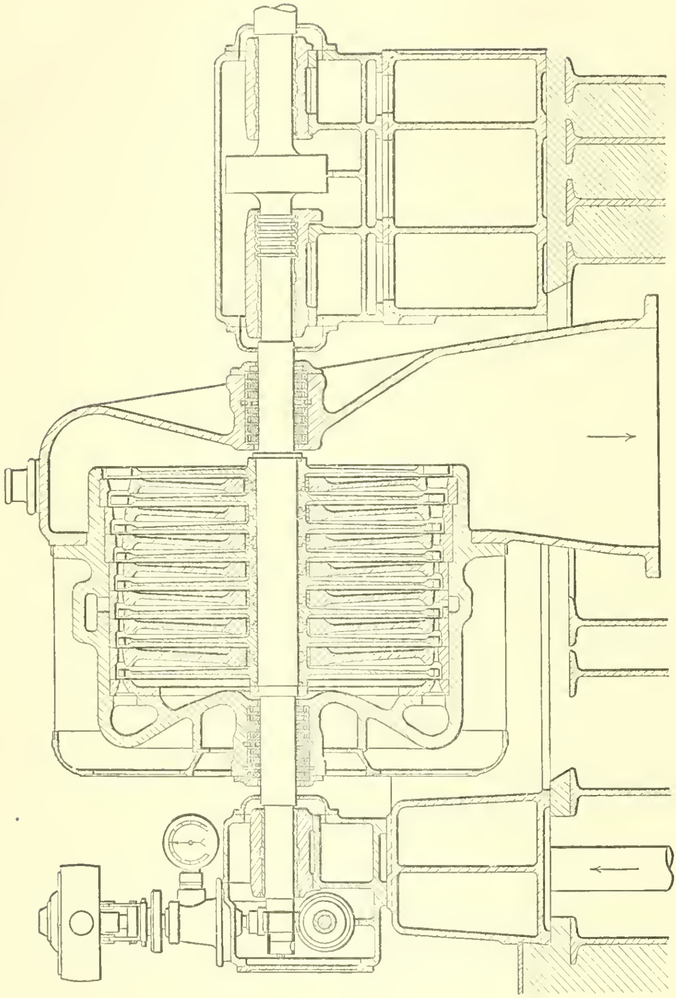


Fig. 1 Section of Zoelly Turbine

gether with the troubles due to distortion in the long shaft, have forced designers to introduce modifications in this portion of the turbine, either by new blading arrangements, by dividing the total expansion in large sizes between two cylinders or by the introduction of impulse blading.

8 The low-pressure sections of Parsons turbines have always shown high efficiencies. As low steam velocities are characteristic of this type, there is no cutting away of blade material, even with very wet steam, provided no injurious properties are present in the feedwater. This low-pressure section has therefore been altered only in details.

9 The presence of a large low-pressure balance piston in close proximity to the steam inlet has frequently been the cause of serious distortions. Many builders now place this balance piston in the exhaust end, a construction due to Fullager.

10 The Curtis turbine utilizes high steam velocities in all stages. As steam becomes wet through expansion in the low-pressure stages, there is frequently considerable cutting of the blade material by the steam, although, contrary to first expectations, there is seldom cutting in the high-pressure blades due to the high initial velocities. The first row of velocity blades in a stage usually does the greater portion of the work, and hence the second row does not work at maximum efficiency. As the steam of the first stage is expanded very fully in the nozzles, there is no high pressure or superheat in the turbine casing or at the glands. The vertical type of unit is sometimes subject to electrical unbalancing and to other troubles peculiar to this construction. It is not as accessible in operation as the horizontal machines.

11 Recent designs have provided for horizontal units and for the replacement of the low-pressure section by sections of other types.

12 The Rateau turbine has high pressures on the gland at one end. There are a large number of disks revolving in dense steam at the high-pressure end. It has lower steam velocities throughout than the Curtis, and consequently has no blade-cutting effects in the low-pressure section. The clearances around the blades are large, but the shaft clearances of the diaphragms must be kept small. Some builders of this and the Curtis type have brought out new designs which employ the high-pressure section of the Curtis with the low-pressure section of the Rateau. These represent a compromise between efficiency and manufacturing costs.

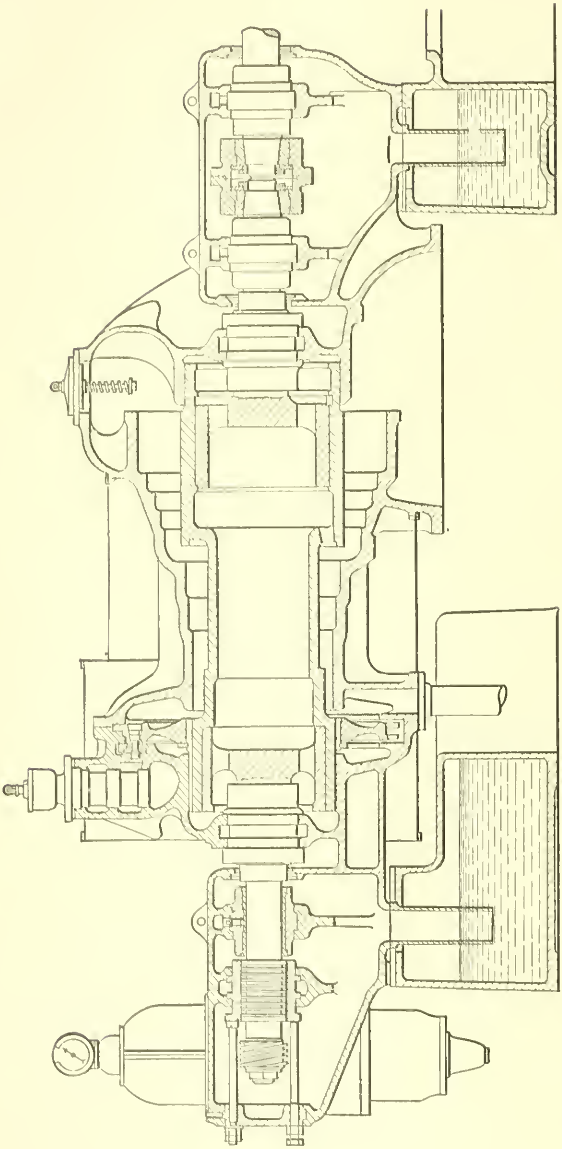


FIG. 2 SECTION OF BROWN BOVERI'S CURTIS-PARSONS TURBINE

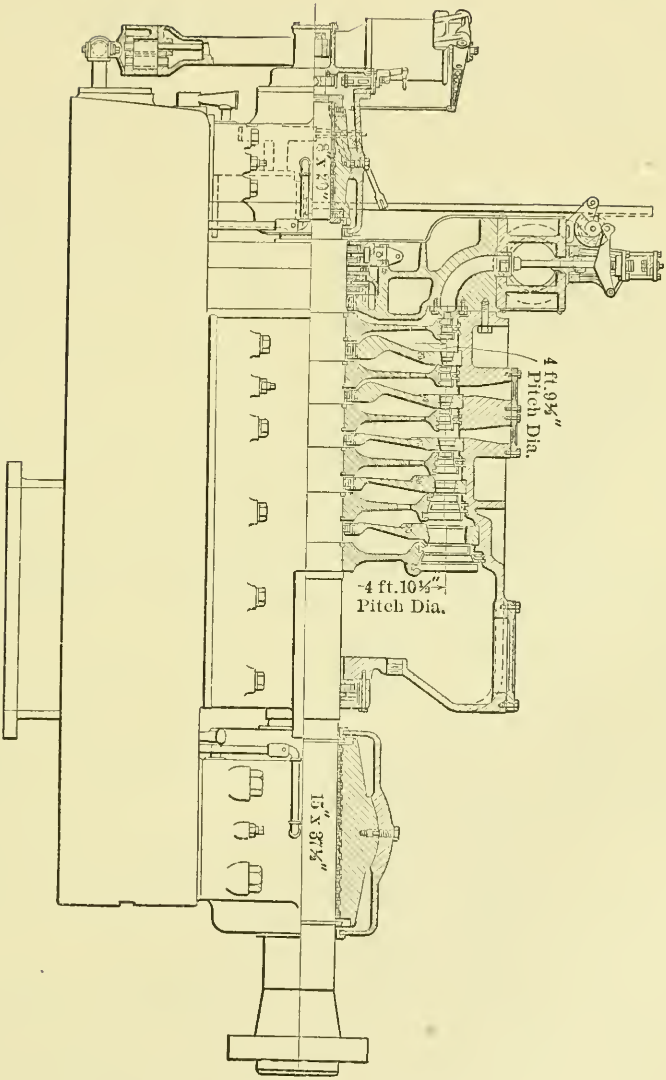


FIG. 3 HORIZONTAL CURTIS STEAM TURBINE, 7000 KW., 1800 R.P.M., SIX-STAGE

13 Under the classification of modified or combined types, there are turbines with modified Parsons, Curtis and Rateau construction, and turbines with combinations of Curtis-Parsons, Rateau-Parsons, Curtis-Rateau and Curtis-Zoelly construction, with a few special combinations. Some typical turbines of these classes are described in the following paragraphs.

14 The Allis-Chalmers Company manufacture a turbine of the modified Parsons type. High peripheral speeds are employed with a decreased number of rows. A portion of the theoretical efficiency in the high-pressure end has been sacrificed by the use of fewer blade rows. Also a smaller proportion of work is done in this section than is usual in Parsons turbines. The blades are all provided with a channel-shaped shroud. European experimenters have pointed out that better efficiencies are obtained with shrouded than with plain blades, as the so-called spilling-over at the ends is prevented. Wing blades are fitted in the last low-pressure rows to take care of the large volumes of low-pressure steam. The spindle is much shorter and stiffer than the standard Parsons, and hence smaller clearances can be provided. The Fullager low-pressure balance piston is also used. The outstanding features of this design are, reaction principle with drum construction, few rows of blades with high steam velocities, short spindle construction, and employment of wing blades for high vacuum. The steam consumptions obtained on this type show improved efficiency over standard construction.

15 A number of Parsons turbines have been built in which the total expansion is divided between two cylinders. One of the best known units of this type is installed at Dunstan Power Station, England. This was built by Richardsons Westgarth & Company on Brown-Boveri designs. This unit, however, employs a modified double-flow Parsons construction in the low-pressure cylinder.

16 C. A. Parsons & Co. have used cast-steel cylinders for the high-pressure portion of their turbines so as to overcome the troubles due to deformation and growth of metal under high pressures and superheat experienced with cast-iron casings.

17 The Westinghouse Machine Company have developed a double-flow machine which employs a Curtis high-pressure stage with Parsons intermediate and double-flow low-pressure sections. There is only one balance piston in this machine next to the Curtis ring. Mr. Sam L. Naphtaly described this type of machine in his

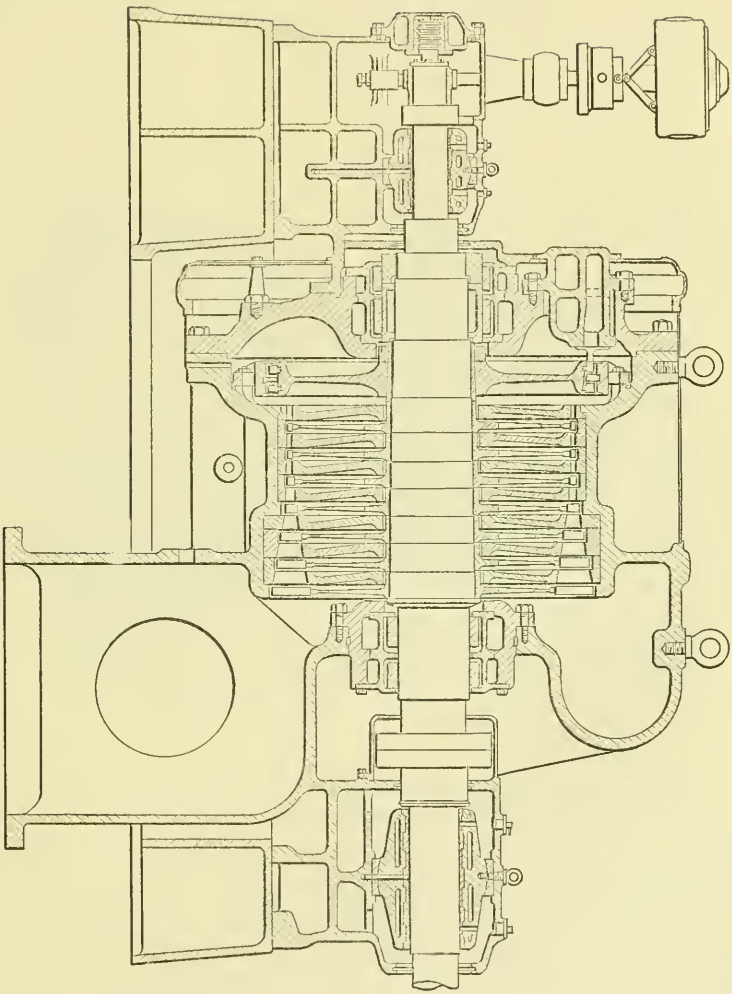


Fig. 4 Section of Bergmann Curtis-Rateau Turbine

paper, "Test of a 10,000-Kw. Steam Turbine," and also showed a cross-section of the turbine.[1]

18 These turbines run at high speeds, have short shafts and small clearances. The steam is expanded in the nozzles, and hence there are no high pressures or temperatures in the casing. By providing two low-pressure sections, high vacuum can be economically utilized.

19 European builders of Parsons turbines, among whom are Brown Boveri & Company, C. A. Parsons & Co., Franco Tosi, Sulzers, Willans & Robinson and Erste Brünner, have replaced the high-pressure sections of their Parsons turbines by a Curtis wheel with two or more velocity rows, but have retained the single-flow Parsons drum construction for the remaining portions. One of these units is shown in Fig. 2. The temperatures and pressures in the casing are low as the steam is expanded in the nozzles. The distance between bearings is decreased, the shaft is stiffer and clearances are smaller than in the standard Parsons turbine. The Fullager balance piston is used in the turbines of several of these builders. Turbines built in this manner have shown some exceptionally good efficiencies.

20 Compared with the Westinghouse machine, the leakage at the end of the low-pressure blading is less than in the double-flow section. On the other hand, the Westinghouse machine has smaller balance piston losses and can also utilize the highest vacuum at better efficiency.

21 Melms & Pfenniger employ a drum impulse section of about five stages instead of a Curtis ring on some of their large turbines. They claim improved efficiency from this construction, though high-pressure and high-temperature steam are introduced into the casing.

22 The General Electric Company now manufacture a horizontal type Curtis turbine in all sizes up to 7000 kw., a section of which is shown in Fig. 3. This embodies all the essential features of the Curtis design. Compared with the vertical type, this design provides easier access to all working parts such as governor, bearings, valves, etc., and allows a better survey of the unit. The machine can also be dismantled and its internal parts examined with less trouble. The oiling problem is very simple compared with the vertical units, as there is no step bearing to provide for. It is possible that only horizontal units of all sizes will be built in the near

[1] Trans. Am. Soc. M. E., vol. 32, p. 1251.

future. The A. E. G. also builds similar turbines up to 1000 kw. capacity.

23 Many manufacturers in Europe are now building a turbine of the type shown in Fig. 4. This consists of a Curtis high-pressure with Rateau or Zoelly low-pressure sections, the number of stages depending on the size of the machine, the speed and the steam conditions. The pressure and temperature in the casing are low, as a consequence of the expansion of the steam in the nozzles. The steam velocity is moderate in the low-pressure section. This ma-

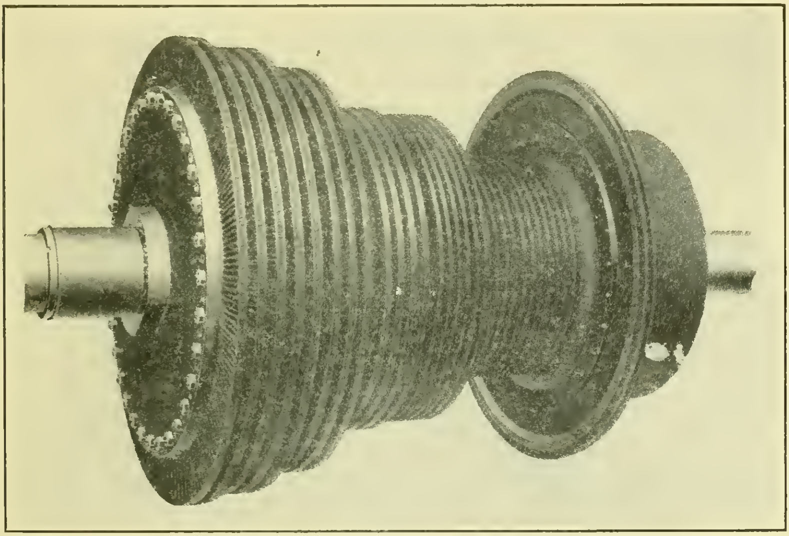


Fig. 5 Spindle of Curtis Drum-Impulse Turbine of Belliss & Morcom

chine is longer than the simple Curtis but shorter than the Rateau. Its builders claim improved efficiencies over either of the fundamental types.

24 Belliss & Morcom, of Birmingham, England, have introduced a turbine, the spindle of which is shown in Fig. 5. It consists of a high-pressure Curtis stage with a low-pressure drum construction like Parsons, but fitted with impulse blading on the spindle and blades forming expansion parallel wall nozzles in the casing. All other impulse turbines employ diaphragms extending to the shaft. There are a greater number of rows in a Belliss turbine than in a corresponding Rateau turbine, and hence a lesser pressure drop through each set of guide blades. The net leakage loss may thus be

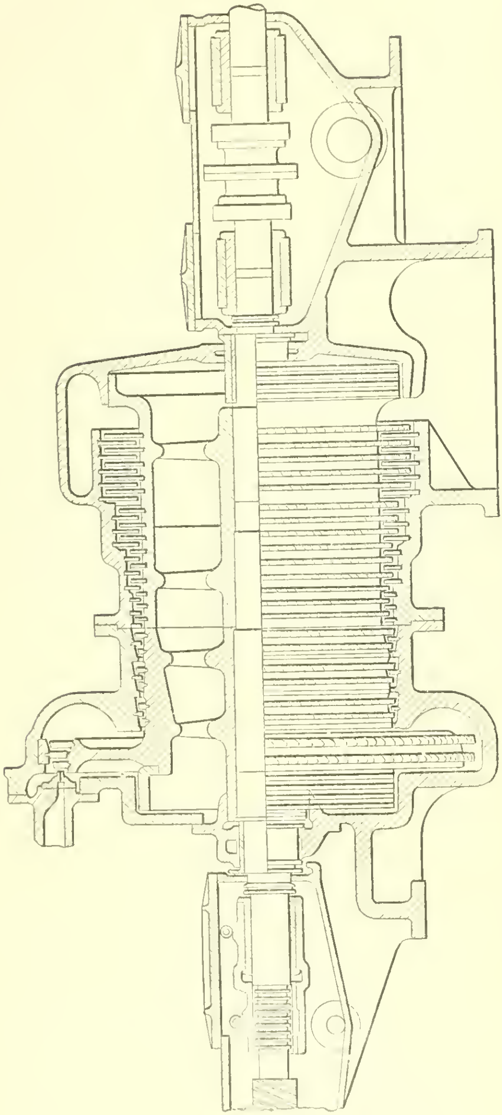


Fig. 6 Section of Curtis Drum-Impulse Parsons Turbine

lower than the Rateau, even though the leakage area is greater. This turbine is essentially a Curtis-Parsons construction, with few rows of blades and with the expansion taking place in the stationary blades only.

25 A turbine, shown in Fig. 6, has recently been patented in England, which has some features of unusual interest. The high-pressure stage is Curtis, the intermediate section is of a drum impulse type with three stages, while the low-pressure portion is Parsons, which may be also double-flow. This combines features of all three fundamental types, and it will be interesting to see what results are obtained in practice by such an arrangement.

DISCUSSION OF TURBINE DETAILS

26 In the early days of steam turbine building it was difficult to secure suitable materials to withstand the stresses set up at high speeds of rotation. But as the demand for such materials increased, much study was given to the requirements for this service so that it has been possible through the use of more suitable material to increase very considerably the speeds of all sizes of steam turbines.

27 Higher steam velocities are possible with increased peripheral speed, and thus fewer rows of blades or stages are required. This results in a shorter and more rigid shaft construction, which is therefore less liable to vibration. Many builders, especially those of Parsons turbines, have found this construction to give an increase in steam economy over the slow-speed types, so that the more compact modern high-speed machine is more desirable than the older type.

BLADING

28 The requirements of a satisfactory blading material are that it shall withstand without deformation stresses due to centrifugal force, and temperature or pressure changes, it shall not cut out with high velocities of steam, and that it shall withstand the corrosive effects of moisture. Parsons turbines have used special bronzes and copper-nickel alloys. Steel blades have also been used in some cases. In these turbines the steam velocities are low and there is usually no cutting on this account. The principal problem with this blading is to manufacture it cheaply and secure it in such a manner that it will withstand all stresses to which it is subjected. This blading design is therefore a question of detail, and, as shown in Table 1, many ingenious schemes have been devised.

29 In Parsons turbines the blades are usually cut, punched or pressed into proper form from strips of drawn material. The original Parsons blading consisted of alternate blades and distance pieces placed in a slightly dovetailed slot and calked tight. Many European builders thread blades and distance pieces on holding wires before calking in. In this case the blading is made up in sections. Other builders of turbines of the Parsons type use Sankey's solid foundation ring held in place by a soft metal calking strip. Allis-Chalmers employ this well-known construction. As this form is usually all machine made, it is considered by many engineers to be safer than where dependence is placed on hand work, such as must ordinarily be done where each distance piece is calked separately.

30 There are many methods in vogue for spacing and reinforcing the ends of Parsons blading. The Westinghouse Machine Company use a comma-shaped wire threaded through the blades near their outer end and bent over between them. Similar schemes are used by manufacturers in Europe. As a rule, however, European builders follow the old Parsons method of silver soldering or brazing the blades to a holding wire near their outer ends. They generally thin down the tips of the blades to reduce weight and to avoid injurious effects to spindle or casing from accidental rubs. Some builders, such as Sulzers, do not thin off their blades or use shrouds, but make their spindles so rigid and well balanced that the blades can be made with a very heavy cross-section and hence need no support. Several manufacturers rivet the outer ends of their blades into channel-shaped shroud rings. This gives an especially stiff construction.

31 Advocates of the shrouded blading claim that it provides a labyrinth passage for the steam and thus reduces the leakage losses from row to row. It also holds the blades at the required angles. It has been noted, however, that with wet steam there is a tendency for the moisture to pit the casing opposite the edges of the shrouds and thus increase the clearances. This action has also been noticed with unshrouded Parsons blading. The shrouded blading is usually so stiff that serious damage is done if rubbing starts between the blading and the spindle or casing.

32 The blading of impulse turbines is of nickel steel, frequently with 25 per cent nickel, in the high-pressure section and special bronze in the other stages. Experience with this 25 per cent nickel steel blading material has not been entirely satisfactory, and several manufacturers are now using a low carbon steel alloy with just sufficient nickel to prevent corrosion, usually about 5 per cent. These

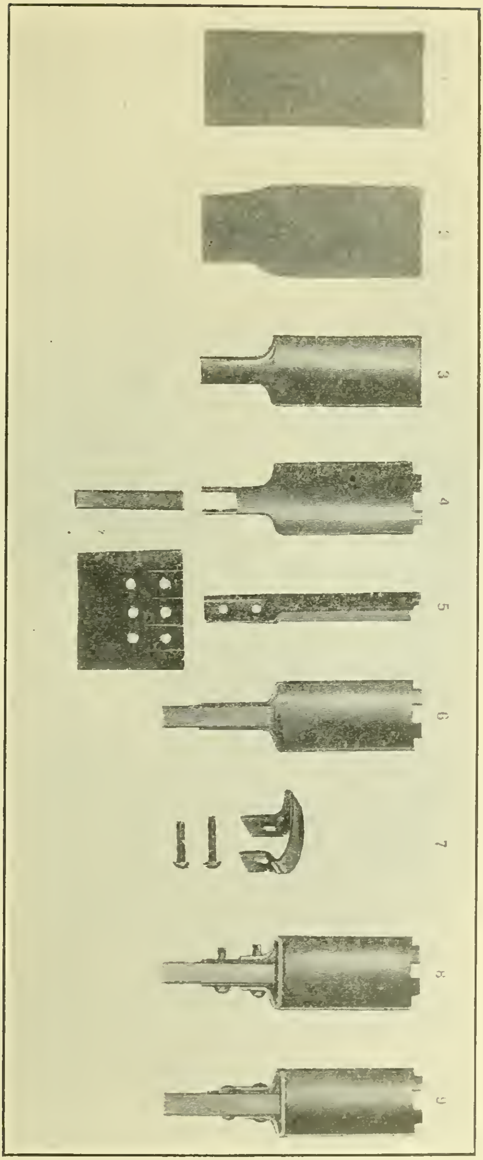
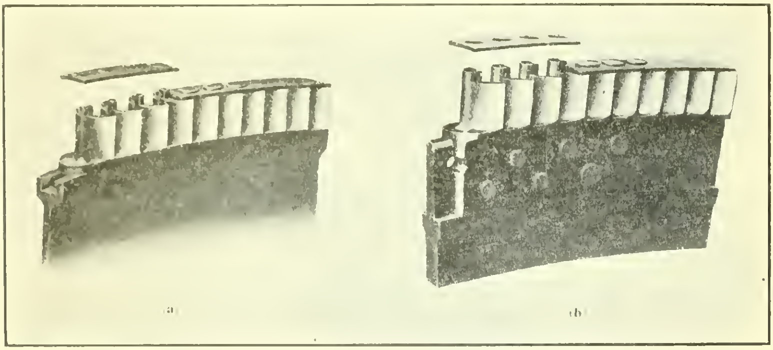


FIG. 7 METHOD OF MANUFACTURE OF BLADING FOR RATEAU SECTIONS OF BERGMANN TURBINE

blades are said to be stronger and less liable to fatigue of material. Special bronze and monel metal have also been successfully used. These impulse blades are stamped from sheets, drop forged or milled from solid bars with or without a wide base to act as a distance piece, or are made from extruded metal strips of the desired cross-section. Usually these blades are of crescent section, but some are formed of flat strip material and made of constant thickness over the width of the blade. The separate distance pieces are usually of the same material as the blades themselves. In general, all impulse blades are provided with shrouds to prevent vibration and also to provide an enclosed passageway for the steam at high velocities. As there



(a) (b)

FIG. 8 TYPES OF BLADING USED BY BRITISH WESTINGHOUSE COMPANY

is no drop in pressure between the two sides of a row of moving blades, the clearance can be made large, both on the end and sides, so that there is little possibility of rubbing when in operation.

33 Impulse blading is usually held in place in dovetailed grooves or in tee-shaped slots, although some manufacturers form their blades with two legs which straddle the disks and are held firmly in place by rivets.

34 The first impulse turbines had blading in which the inlet and discharge angles were equal. Now almost all builders use blading on which the discharge side of the blade makes a sharper angle with the axis than the inlet side. This does not necessarily mean that the discharge area of the blades is smaller than the inlet area, for the blade is usually lengthened radially on the discharge side. Thus both inlet and discharge areas are made equal. The sharper angle of discharge reduces slightly the relative velocity of exhaust from the moving blade. On turbines of the Curtis type there is usually

only a small difference between the inlet and outlet angles of the first row of moving blades, but on the second row of moving blades in the stage, the entrance and exit angles often differ by as much as 15 deg.

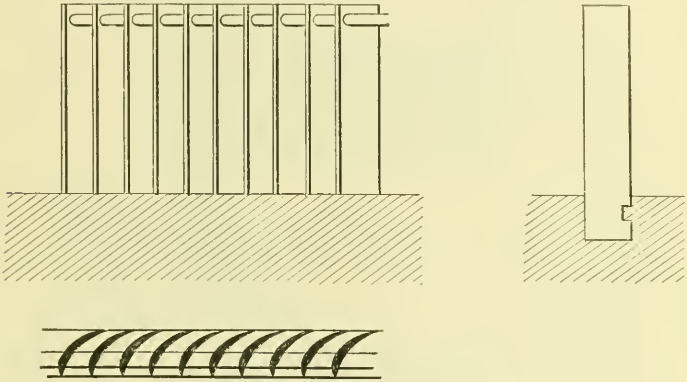


Fig. 9 Brown Boveri's Reaction Blading

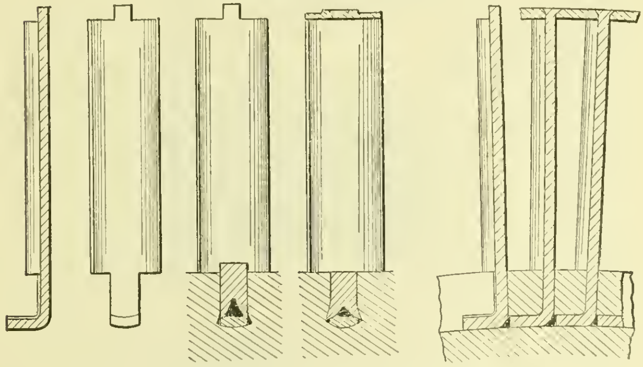


Fig. 10 Belliss & Morcom Impulse Blading

35 Some impulse turbine designs are such that there must evidently be some such reaction effect in the moving blades as is obtained in Parsons turbines, though not of sufficient amount to cause any noticeable end thrust.

36 Some recent interesting developments in blading are shown in Figs. 7-11. Fig. 7 shows the various steps in the manufacture of the thin sheet metal blading used by Bergmann. The blading of the Rateau disks of British Westinghouse turbines is clearly illustrated in Fig. 8. Brown Boveri's form of Parsons blading is illustrated in

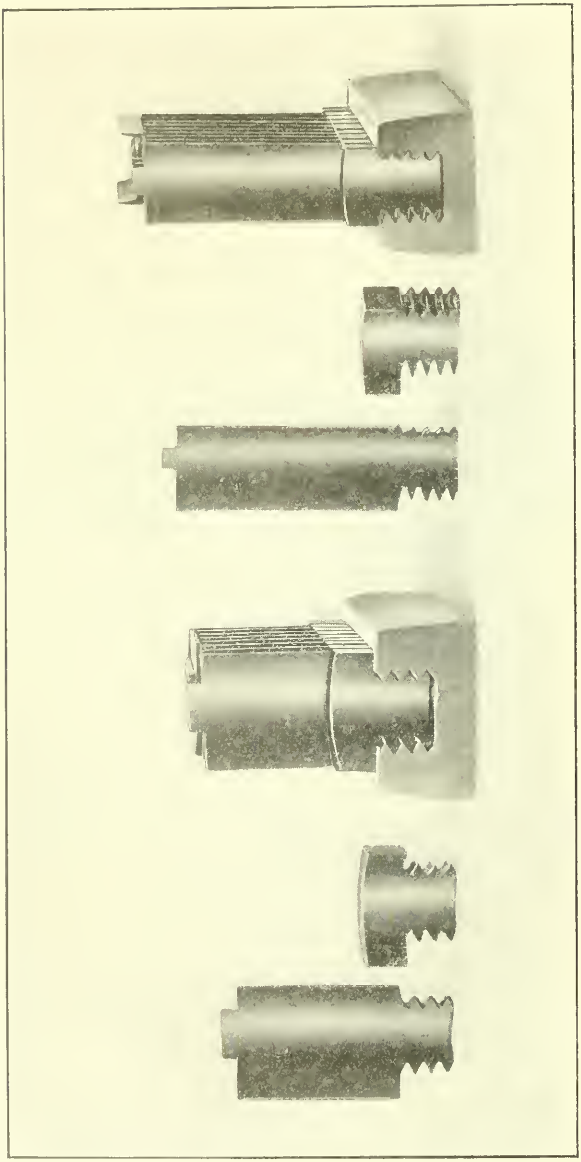


Fig. 11 Franco Tosi's Blading. Impulse Blades on Left, Reaction Blades on Right

Fig. 9. Belliss & Morcom use a unique form of blading on the drum impulse section. This blading is shown in Fig. 10. Franco Tosi cuts projections like threads in his blade grooves and mills corresponding projections on the base of the blades, as in Fig. 11. This is a very satisfactory but expensive form of blading.

37 The number of rows of blades in any given type depends entirely on the size and speed of the unit, the steam conditions under which the turbine will operate and the heat drop per row or stage assumed in the design. Each designer selects such conditions as his experience and judgment lead him to consider the most satisfactory. It is thus hard to draw any general conclusions as to the most desirable number of rows for any class of turbine. In general, it may be said that the Parsons turbines require from 40 to 80 sets of moving and stationary blades, the Curtis from 4 to 8 stages, the Rateau from 12 to 25 stages, the Zoelly from 8 to 20 stages, while the Curtis-Parsons and Curtis-Rateau combinations of course require several rows less than the fundamental types.

NOZZLES

38 The high-pressure nozzles in impulse or combination turbines are made of bronze or nickel steel highly polished inside and placed either in the upper end of the casing itself, or, more preferably, in a separate steel casting which bolts upon the casing. In the latter construction the casing itself is never subjected to the high temperature or pressure of the entering steam.

39 The nozzles in the diaphragms between stages are usually made of nickel steel or other special steel, bent to the proper form and cast in place in the diaphragm body. Some manufacturers use brass nozzles in place of steel made up in sections and riveted or bolted in place. All these passages must be smooth and preferably very highly polished to reduce friction losses. After the first stage all nozzles have parallel walls on the discharge side.

BEARINGS AND LUBRICATION

40 Practice varies widely with regard to the design and construction of journals and bearings. Builders of impulse turbines invariably use cast-iron bearing shells provided with spherical self-aligning pads and lined with white metal. These are being used to an increasing extent on Parsons turbines and without exception on all low-speed units. Some manufacturers still retain the original Parsons form of bronze bearing shell with concentric rings on the

outside, separated from each other by oil films. It has been claimed for this type of bearing that the oil films dampen any slight variation of the spindle and thus provide a quieter running machine. Experience has shown that this is not always the case and that such a bearing is often a real source of danger when the added clearance of the spindle due to play between the rings is taken into consideration. This construction is also much more expensive than the white metal bearings.

41 In Europe many turbines are run with a minimum amount of oil and with oil leaving the bearings at a temperature of 190 deg. fahr. This practice is based on the argument that such a system of lubrication requires the least expenditure of power for oil circulation and in friction losses. However, practice seems to be tending towards flooded lubrication, in which a great quantity of oil at a temperature of about 100 deg. fahr. is forced through the bearings by a pump of the rotary, centrifugal or gear type, driven from the main shaft of the turbine. The oil pressure at the bearings varies from 3 to 20 lb. per sq. in. The life of the oil is much longer in this system than with very hot oil and any wear on the bearings themselves is absolutely prevented. Occasionally the bearing shells are water-cooled, but this practice should be discouraged. Cooling water can be used much more satisfactorily outside of small oil pipes in properly designed coolers. In case the water is dirty or full of scale-forming impurities, these can be more readily removed from an oil cooler than from the interior of a bearing shell.

42 Flooded lubrication has enabled manufacturers to cut down the length of their bearings and thus reduce the total length of their turbines. The increased pressures per unit area on the bearings have not introduced any difficulties, so that pressures of 80 to 100 lb. per sq. in. at a surface speed of 60 ft. per minute are common practice. The best results are usually obtained with a temperature of about 125 deg. fahr. as the oil leaves the bearings.

SPINDLE CONSTRUCTION

43 Parsons turbines in America are usually built with a hollow quill into which the journal ends are forced and fastened by shrink links or bolts. The high-pressure blading is placed in grooves in one end of the quill itself. The intermediate and low-pressure blades are usually carried on cast or forged-steel rings which are afterwards forced and keyed upon the central quill. In Europe excellent hollow steel forgings can be obtained very readily, and hence the spindles

of Parsons and other drum type turbines are usually made up of one forging with the journal shafts fastened into the ends.

44 The shafts of impulse turbines are usually in one piece and carry the blade disks, which are high-grade steel or nickel-steel forgings or castings. These disks are fitted and keyed on the shaft and held in place by shrink links or lock nuts.

45 It is quite general practice now to design the shafts so that the normal speed of the turbine will be very considerably below the critical speed due to any slight unbalancing of the mass that may be present. This removes the dangerous vibrations often experienced when passing through critical speeds and permits closer clearances to be used on Parsons blading and in the labyrinth passages in the diaphragms between the stages of impulse turbines.

PACKING GLANDS

46 A small impeller supplied with water is provided on all American built Parsons turbines to form an air seal at the shaft glands. European builders prefer to use labyrinth packings with live or throttled steam as an air seal. The objection raised by foreign builders to the water packing is that it takes too much power to drive the impeller, and that it provides a condensing surface for the steam. The amount of water required in a well-designed gland is very small, and there is no great circulation. Thus the water can have only a small effect as a condensing medium. Usually the steam directly inside the casing is under vacuum and then condensation would not be objectionable. It requires considerable steam to pack the labyrinth type of gland, and this loss often exceeds that due to the power required to drive the water impellers.

47 Impulse turbines use carbon rings at the high-pressure gland, especially when superheated steam is used. The leakage past the first rings is carried through a passage and pipe to the low-pressure glands to act as a vacuum seal. The labyrinth packing in the diaphragms is usually of bronze in the high-pressure stages and frequently of white metal in the low-pressure section. The low-pressure shaft glands are made either with carbon or labyrinth packing, sealed by steam.

THRUST BEARINGS

48 Thrust bearings are now provided on all types of turbines. These serve to adjust the position of the spindle and to take up any end thrust present. The end thrust in well designed turbines is

usually of small amount and seldom causes trouble. These bearings are usually flooded with oil and are often made with bronze rings which can easily be replaced in case of damage.

49 Several builders of Curtis-Parsons turbines have substituted an oil thrust piston for the steam balance piston of the usual form. This piston is placed on the governor end of the shaft outside of the casing proper. The thrust is taken up by oil which is supplied under pressure and which can escape only through sets of labyrinth baffles on the piston and on the surrounding chamber. The piston adjusts itself for the amount of thrust present by a small axial movement of the shaft, thus opening or closing the discharge area for the oil through the labyrinth baffles, and automatically varies the oil pressure on the face of the piston. This arrangement does away with the loss of steam through balance pistons and should improve the turbine efficiency, though a small amount of power is required to pump the oil.

GOVERNING DEVICES

50 The speed of Parsons turbines is usually controlled by a centrifugal governor of the Hartung or similar type which regulates the position of a balanced poppet valve through the medium of a steam or oil relay. The latter type is coming into more general use on account of its many advantages over the steam relay. The steam is throttled either at constant pressure or by a pulsating action.

51 Impulse turbines and turbines employing a Curtis high-pressure ring usually govern by means of Hartung type governors and oil relays. The speed is sometimes controlled by simple throttling of the steam, which practice is common in Europe. In this case, additional nozzles can be opened or closed by hand as required. This system would be unsuitable with violently fluctuating loads. Other types employ both throttling and automatic nozzle regulation, while, again, many turbines, particularly of the Curtis type, are built for nozzle governing alone. In Europe there is a difference of opinion as to the most economical method of governing. M. H. Zoelly claims that he gets the best results on his type of turbine by throttle governing. It is generally admitted, however, that impulse turbines give the best results by controlling the number of nozzles that are open at any load. With such control the pressure before the nozzles in service is always the normal pressure for which these are designed. The General Electric Company govern their turbines above 300 kw. by means of an oil relay system which oper-

ates through a piston and camshaft to open or close nozzles as required by load conditions.

52 The Westinghouse Machine Company use a vibrating oil relay system on many of their machines. Recently they have adopted on some sizes a very powerful governor which is direct-connected to the governing valve and operates it without the use of relays. This system was adopted by some of the early European builders, but was abandoned in favor of the oil relay system.

53 Sulzers have recently installed turbines in which the conventional centrifugal force governor has been replaced by a hydraulic governor. This governor consists of a simple centrifugal pump, geared to the main shaft and delivering oil under pressure into a chamber beneath a spring loaded piston. The pressure under this piston is thus dependent on the speed of the main turbine and the piston's position in its cylinder will vary accordingly. The piston is connected to the usual balanced valve of an oil relay which controls the oil supply from the main oil pump to the throttle valve in the usual manner. There are no mechanical parts to wear in this arrangement. The apparatus is extremely simple and has many distinct advantages.

54 All turbines are now provided with a small overspeed governor, usually placed at the outside end of the shaft. This operates at a determined percentage over speed and closes the main or secondary steam valve either by means of a steam or oil relay or by a falling weight through a system of levers and springs. The oil relay system has the advantage that the valve shuts immediately should the oil supply fail for any reason.

55 Parsons turbines are usually provided with a secondary overload valve which automatically admits live steam to the second diameter of blades. Impulse turbines have additional sets of nozzles with valves which may be opened automatically, or by hand in case of overloads.

CASINGS

56 Practice varies widely in regard to the construction of turbine casings. These are generally made of cast iron, though some European builders make the high-pressure front end of cast steel. Parsons turbines are built with the top and bottom halves single castings or made in sections. Some of the older designs of impulse turbines used solid diaphragm plates placed on the shaft between the disks. The clumsiness of handling and the difficulty of making repairs with

this construction has forced most builders to make these in halves and to fasten them to the top and bottom portions of the casing.

57 Cylinder casings are now made of symmetrical design and without any deep metal webs or ribs as stiffeners on the outside. Equalizing pipes with provision for expansion take the place of passages formerly cast in the casings themselves. Strains due to unequal temperatures must be avoided in all portions.

BED-PLATES

58 Several European builders make a practice of filling the hollow portions of their turbine and generator bed-plates with concrete after erection. This adds more mass to the turbine unit and is said to dampen any slight vibration that may be present.

TURBO-GENERATORS

59 A discussion of the design of turbo-generators is beyond the limits of this paper. In general, European builders of electrical machinery allow less overload capacity than is usual on American machines, but give better guarantees of efficiency and regulation.

60 Practice varies widely in regard to the normal rating and maximum capacities of different turbines. Some European builders guarantee their generators to carry normal full load without undue heating only for two to six hours. Others follow the practice which has been introduced in America of rating their turbines at the maximum load they will carry continuously. Several builders still offer turbines which will carry as high as 25 per cent overload continuously.

61 Such conditions are very confusing to purchasers. The time seems opportune for this Society to fix a standard for the rating of steam turbines and to define the overload capacity which may be expected of this type of engine.

COMMERCIAL CONSIDERATIONS

62 When steam turbines are to be installed at high altitudes, as in many locations in the west, the effect of altitude on economy frequently comes up. It can be easily shown that with the same boiler pressure and the same absolute pressure in the condenser, the steam consumption of a turbine at 5000 ft. elevation should exceed that of a similar turbine at sea level by less than 1 per cent.

63 Each turbine is designed to operate at maximum efficiency at some given vacuum. Owing to uncertainties in design factors

for losses and to slight inaccuracies in construction, the most efficient vacuum may vary somewhat from that for which the turbine was designed. Theoretically, the steam consumption should decrease as the vacuum increases, but this rate of decrease will vary for each type of turbine, depending on the blade areas and steam velocities of the low-pressure section. It is, therefore, essential that this rate of change be determined for each individual turbine by actual test.

64 In the purchase of steam turbines, operating efficiency and costs should be considered together with first cost, and the machine selected should be the one on which the ultimate operating and fixed charges are a minimum. This practice is followed in Europe. In America the bargain-counter idea unfortunately possesses many engineers, and manufacturers have frequently been forced to sacrifice efficiency in order to meet competition.

65 In Table 1 some data are presented in tabulated form regarding various types of steam turbines. This information was gathered during personal visits to the various works and also by correspondence. Designs of steam turbine details are constantly changing, so that many of the items in this table may not correctly represent the latest practice of the various builders.

RESULTS OF TESTS

66 The efficiency of a steam turbine may be expressed in terms of pounds of steam per kw-hr., as an efficiency ratio or as the b.t.u. required per kw-hr.

67 The steam consumption is dependent on the initial steam pressure, its temperature or quality, and the condenser pressure. These factors vary in almost every test and the effect of a variation in each is not the same for all classes of turbines. Hence, different turbines cannot usually be compared satisfactorily on the basis of their steam consumption alone.

68 If the steam could expand freely to exhaust pressure in a turbine without radiation, friction, eddy or windage losses, its expansion would be adiabatic and on the Rankine cycle. The "efficiency ratio" expresses the proportion of the heat actually turned into work to that available from such an adiabatic expansion. In other words, it expresses the efficiency of the actual turbine as compared to the ideal turbine, and is independent of the type of turbine.

69 The b.t.u. per kw-hr. is figured above the heat of the liquid at exhaust pressure. This is not a satisfactory standard by which

TABLE 1 DATA ON STEAM TURBINE CONSTRUCTION

Manufacturer	Type of Turbine	R.P.M. of Various Sizes	No. of Stages	Blade Speed in Ft. per Sec.	Steam Velocities, Ft. per Sec.	Blade Material
C. A. Parsons & Co.	Parsons & Curtis-Parsons	....	Usually about 70	270 on low-pressure blades	540	Special bronze and delta metal.
Westinghouse Mach. Co.	Parsons & Curtis-Parsons	Up to 3000 kw., 3600; 3000-5000 kw., 1800; over 5000 kw. (750 or 720)	....	Curtis blades 600; Parsons blades 350	Curtis 2000; Parsons 600	Special bronze and soft steel; Curtis blades bronze
Willans & Robinson.	Curtis-Parsons	....	1 Curtis; 12-20 rows Parsons on 1 diameter of drum	....	....	Bronze and copper-nickel blades
Brown Boveri & Co., Richardsons Westgarth & Co.	Parsons & Curtis-Parsons	Up to 3000 kw., 3000; 3000-7500 kw., 1500	....	Curtis blades 460. Parsons blades 380	....	Curtis blades of special alloy; Parsons blades of bronze
Brush Electrical Engrg. Co.	Curtis-Parsons	....	....	....	....	Parsons blades bronze alloy
Erste Brünner M. F. G.	Curtis-Parsons	Up to 1500 kw., 3000; 1500-4000 kw., 1500; 4000 kw., up, 960	1 Curtis; remainder Parsons on 2 diameters of drums	....	....	Both Parsons and Curtis blades of special bronze
Franco Tosi.	Curtis-Parsons	Up to 2500 kw., 3000; 2500-8000 kw., 1500; 8000-12,000 kw., 1000	1 Curtis; remainder Parsons on 1 diameter of drum	....	Curtis 2130; Parsons 230-460	Parsons and Curtis blades of special bronze
Gebrüder Sulzer.	Curtis-Parsons	....	....	Curtis blades 360; Parsons blades 310	....	Curtis blades all of special steel; Parsons blades of special bronze
Melms & Pfenninger, Breitfeld, Danek & Co.	Rateau-Parsons & Curtis-Parsons	Up to 4000 kw., 3000; 4000-9000 kw., 1500	....	Up to 575	Impulse section up to 2200; Parsons up to 900	Rateau blades of special bronze; Parsons blades also special bronze
Allis-Chalmers Co.	Parsons	Up to 2000 kw., 3600; 2000-5000 kw., 1800	....	Up to 370	400-800	Copper-nickel alloy
Allegemeine Electricitäts Gesellschaft.	Curtis-Rateau	Up to 3000 kw., 3000; 3000-9000 kw., 1500; 9000 kw. and over, 1000	1 Curtis; 9-12 Rateau	....	....	Bronze alloy or nickel-steel

Maschinenfabrik Augsburg Nurnberg.	Curtis-Zoelly	Up to 6000 kw., 3000; 6000-10,000 kw., 1500; 10,000-15,000 kw. 1000	1 Curtis; 6-8 Zoelly	Up to 650	Curtis 2500; Zoelly about 1300	Nickel-steel highly polished
British Westinghouse Co.	Curtis-Rateau	Up to 1500 kw., 3000; 1500-5000 kw., 1500	1 Curtis; 6-12 Rateau	300-500	Curtis 1500; Rateau 800	5% nickel-steel
Bergmann Electricitäts Werke.	Curtis-Rateau	....	1 Curtis; 8-12 Zoelly	410-460	Curtis 2600; Rateau 1170	25% nickel-steel
Belliss & Morcom.	Curtis-Drum Impulse	Up to 1500 kw., 1800; use lower speeds than most builders	1 Curtis; 25-30 rows of impulse blades on drum	Not exceeding 400	....	Curtis blades of steel; Impulse blades of phosphor bronze
Escher, Wyss & Co.	Zoelly	Up to 1500 kw., 3000; 1500-3500 kw., 1500; over 3500 kw., 1000	3000 r.p.m., 10 stages; 1500, 16 stages; 1000, 20 stages	....	About 1400	5% nickel-steel
Maschinenfabrik Oerlikon.	Rateau	Up to 4000 kw., 3000; 4000-7500 kw., 1500; over 7500 kw., 750	10-16 stages with 2 or more mean diameters of blades	320-520	1310-1700	Nickel-steel
Sachsische Maschinenfabrik.	Zoelly	....	5-6 on first diameter, 6-8 on second diameter	....	....	Nickel-steel
Frazer & Chalmers.	Rateau	....	Are reducing number of stages on all turbines	Have increased blade speeds recently	....	Nickel-steel
Pokorny & Wittekind.	Curtis-Rateau & Rateau	....	....	500-600	2300 admission	....
General Electric Co.	Curtis	Up to 1400 kw., 3600; 1400-7000 kw., 1800; 7000-20,000 kw. (750 or 720)	4-7	460-500	About 1200 average	Special bronze extruded metal, Monel metal and steel used on some low-pressure blades
British Thomson Houston Co.	Curtis	Up to 1000 kw., 3600; 1000-5000 kw., 1800; up to 2000 kw., 3000; 2000-7500 kw., 1500	Same construction as General Electric Co.	600 as maximum	About 1800 from nozzles, 1100 from diaphragms	Special bronze and steel

TABLE 1—*Continued*

Manufacturer	Blade Form	Method of Blade Manufacture and Insertion
C. A. Parsons & Co.	Parsons form with very thick rounded inlet, blades thinned off at tips	Alternate distance pieces held by calking, ends of blades stiffened by silver soldering to a brass strip; Curtis blades shrouded
Westinghouse Mach. Co.	Blades crescent with heavy central portion and sharp inlet edge, dovetail base on impulse	Alternate distance pieces held by calking, ends stiffened by comma wire threaded through blades and bent over
Willans & Robinson.	Parsons rounded inlet, stamped to fit Sankey foundation ring and channel shroud; usual Curtis blades on impulse	Parsons sections made up by machine and held in place by calking in soft metal strip, final riveting of shroud completed last
Brown Boveri & Co., Richardsons Westgarth & Co.	Parsons blades not thinned off, usual form, base of blade notched to fit corresponding lateral projection in the grooves, blades not calked	Curtis blades in dovetail slot, no sharp corners on base and shrouded; Parsons blades threaded on wire and silver soldered
Brush Electrical Engrg. Co.	Usual Parsons form with calked distance pieces in dovetailed groove; also use grooved base of blades fitting corresponding grooves in shaft like teeth in a bolt	Tips of blades thinned off, blades silver soldered to wire strip
Erste Brünner M. F. G.	Curtis blades have special dovetail base and are separate from their distance pieces; Parsons blades usual form with distance pieces in dovetail groove	Curtis blades shrouded: Parsons blades thinned at tips and silver soldered to wire on side
Franco Tosi.	Blades and distance pieces milled at base, with thread-like projections to fit corresponding grooves in spindle	Curtis blades shrouded: Parsons blades also have channel shroud-riveted over after blades are in place
Gebrüder Sulzer.	Parsons blades of very heavy cross-section with standard Parsons distance piece and method of calking	Parsons blades not thinned at ends or reinforced in any way; Curtis blades milled to fit dovetail slot
Melms & Pfenninger, Breitfeld, Danek & Co.	Impulse blades have slot in side to fit projection in groove and held in place by soft metal calking strip: Parsons blades have special base to fit foundation ring and with special shroud on end	Parsons blade rings made up in halves and fitted to machine, sections held in place by soft metal calking strip, angle of blades, 20 to 45 deg.

Allis-Chalmers Co.	Parsons section with more defined inlet edge, blading uses Sankey foundation ring and shroud, blading made in sections outside turbine	Sections held in dovetailed slots by soft metal calking strips, shrouds channel-shaped
Allegemeine Electricitäts Gesellschaft.	Blade crescent shaped but of lighter section toward exhaust end, shrouded in groups	Blades cut from solid bar and set in dovetailed grooves with separate distance pieces
Maschinenfabrik Augsburg Nurnberg.	First Curtis rows have blades of heavy section, remaining rows are thin in section, blades are held in a $\perp$ slot	Blades mostly drop-forged, all rows shrouded, outlet and inlet angles vary considerably
British Westinghouse Co.	Curtis blades have $\perp$ base to fit corresponding groove; Rateau blades have 2 projections at base straddling disk and rivets rolled in place	Blade and distance pieces milled from solid steel bars
Bergmann Electricitäts Werke.	Blades stamped from sheet metal with projections at base straddling disk and riveted to it, blades of uniform thickness across section	Distance pieces drop-forged of special bronze and riveted with blades to disk, all blades shrouded
Belliss & Morcom.	Curtis blades, usual form; on impulse section blades are of uniform thickness over section and shrouded	Blades made with strip at base bent in form of L, distance piece formed with opening at base, the 2 projections spread over base of blade and fill dovetailed slot when calked down
Escher, Wyss & Co.	Blades stamped from sheet metal with $\perp$ base, blades sometimes thinned off toward tips, distance piece stands well above surface of shaft	Blades milled with sharp edges and highly polished after stamping, distance pieces milled from solid bar, only thin shroud ring used
Maschinenfabrik Oerlikon.	Blades punched to shape from drawn metal strips, base is $\perp$ shaped, simple band shroud ring used	Distance pieces milled, slot closed by special locking piece
Sachsische Maschinenfabrik.	Zoelly blades thinned off toward tips on low-pressure end, base $\perp$ shaped with rounded corners	Blades and distance pieces milled from solid bar, channel-shaped shroud
Frazer & Chalmers.	Blades with forked base riveted to disks	Blades milled from solid bar, no shroud ring, but head milled on blades like De Laval
Pokorny & Wittekind.	High-pressure blades shrouded, low-pressure blades unshrouded on some units	....
General Electric Co.	Blades milled with dovetail base and have shroud ring, distance pieces also milled	Blades put in place in special blading machine
British Thomson Houston Co.	Same construction as General Electric Co.	Same construction as General Electric Co.

TABLE 1—*Continued*

Manufacturer	Nozzles and Diaphragms	Shaft and Spindle Construction	Form and Material of Bearings
C. A. Parsons & Co.	....	Spindles usually a single hollow forging, shaft ends fastened in	Parsons concentric bronze sleeve bearings in self-aligning cast-iron casings, large sizes white metal lined
Westinghouse Mach. Co.	....	Shaft, hollow quill with blade rings forced on, ends held in by special patented fastening	Parsons concentric sleeve bearing on small units, cast-iron self-aligning bearings, white metal lined on large units
Willans & Robinson	....	Disk, solid forging; drum, hollow rolled forging; ends fastened in by locked bolts; Fullager balance piston used	Cast-iron, white metal lined, self-aligning
Brown Boveri & Co., Richardsons Westgarth & Co.	Nozzles made in 3 parts of steel or bronze and all machined	Disk, solid forging forced and fastened on hollow forged drum spindle; shaft ends locked into drum; Fullager balance piston used	Parsons concentric bearings on high speeds, cast-iron, white metal lined, self-adjusting bearings on low speeds
Brush Electrical Engrg. Co.	....	Disk, solid and fastened on solid or hollow forged drum spindle	Cast-iron, white metal lined, self-adjusting bearings on all sizes
Erste Brünner M. F. G.	Nozzles of special bronze alloy	Small sizes, nickel-steel, solid rotors; large sizes, hollow forged high grade steel; Curtis ring bolted to spindle	Parsons concentric sleeve bearings on small units; on large units cast-iron white metal lined self-aligning bearings
Franco Tosi.	Nozzles of steel or bronze, angles of nozzles 20 to 25 deg.	Forged steel shaft with spindle rings and impulse disk with balance piston forced on and held by bolts	Cast-iron, white metal lined, self-aligning bearings
Gebrüder Sulzer.	Nozzles of sheet brass cast in valve chest	Spindle, hollow forging with shaft ends and impulse disk bolted on	Cast-iron, white metal lined, self-aligning bearings
Melms & Pfenninger, Breitfeld, Danek & Co.	Nickel-steel guide blades in Rateau section with special labyrinth packing, angle of nozzles 18 deg. to 22 deg.	Spindle, hollow forging of nickel-steel, impulse disk and balance piston fastened on; shaft ends forced in	Parsons concentric sleeve bearings on small units, large units have cast-iron, white metal lined, self-aligning bearings
Allis-Chalmers Co.	....	Hollow forged quill with blade rings of cast steel forced on; shaft ends forced into quill and held by bolts and buts; Fullager balance piston	Cast-iron, white metal lined, self-adjusting bearings

Allegemeine Electricitäts Gesellschaft.	Nozzles of bronze or nickel-steel, guide blades in diaphragms of nickel-steel cast in place	Solid shaft with disks forced on; disks of steel tapering toward the blades	Cast-iron, white metal lined bearings, usually water-cooled; only 3 bearings; very small governor bearing carried by front housing
Maschinenfabrik Augsburg, Nurnberg.	Nozzles of nickel-steel milled from solid, guide blades in diaphragms of highly polished sheet nickel-steel	Short stiff solid shaft running below critical speed disks of soft steel forced on shaft and locked; disks taper toward blade ends	Cast-iron, white metal lined, self-adjusting bearings; only 3 bearings used; governor bearing very small
British Westinghouse Co.	Nozzles of special steel, guide blades of special steel cast in place in diaphragms	Short, solid, stiff shaft stepped from center to receive disks which are of forged steel tapering from center to periphery	Cast-iron, white metal lined, self-adjusting bearings
Bergmann Electricitäts Werke.	Nickel-steel nozzles in 4 groups, nickel-steel guide blades cast in place in diaphragms	Short, solid shafts not too stiff, as shafts at 3000 r.p.m. and over, run above critical speed; disks forced on shaft and locked.	Cast-iron, white metal lined, self-adjusting water-cooled bearings
Belliss & Morcom.	Nozzles, steel or bronze, impulse guide blades of brass made in segments	Forged steel drum fastened to through solid shaft; drum carries impure disk and balance piston; heavy rigid construction.	Cast-iron, white metal lined, self-adjusting bearings
Escher, Wyss & Co.	All nozzles and guide blades of nickel-steel cast in place and highly polished	Solid shaft with disks supported on ⊥ ring so as to make shaft less rigid	Cast-iron, white metal lined, self-adjusting bearings
Maschinenfabrik Oerlikon.	Nickel-steel guide blades all cast in place	Nickel-steel shafts made heavy in the center: disks of forged soft steel forced on and locked to shaft	Cast-iron, white metal lined, self-aligning bearings, water-cooled in the larger sizes
Sachsische Maschinenfabrik.	Sheet-steel guide blades cast in place	Solid shaft with nickel-steel disks, highly polished, forced on	Cast-iron, white metal lined, self-adjusting, water-cooled bearings
Frazer & Chalmers.	Diaphragm guide blades cast in place	Solid shaft with disks forced on	Cast-iron, white metal lined, self-adjusting bearings
Pokorny & Wittekind.	Angle of nozzles 20 deg.	Solid shaft with disks forced on	Cast-iron, white metal lined bearings
General Electric Co.	Inlet nozzles of special bronze, steel guide blades in diaphragms cast in place and polished	Shaft, solid forgings; disks, cast steel forced on shaft	Cast-iron, white metal lined, self-adjusting bearings with copper cooling pipes cast in babbitt metal lining
British Thomson Houston Co.	Same construction as General Electric Co.	Shaft and disks of steel	....

TABLE I—*Continued*

Manufacturer	Surface Speed of Journals, Ft. per Sec.	Bearing Pressure, Lb. per Sq. In.	Type of Oil Pump	Governor and Method of Governing
C. A. Parsons & Co.	35-50	40-50	....	Steam relay system, steam admitted in puffs, not continuous throttling
Westinghouse Mach. Co.	40-50	50-70	Rotary oil pump with sliding gate	Direct throttling from governor, sometimes pulsating; also pulsating oil relay
Willans & Robinson.	45-60	50-70	Both reciprocating and rotary types used	Direct throttling from governor
Brown Boveri & Co., Richardsons Westgarth & Co.	....	....	Rotary pump	Hartung type with oil relay, also slight pulsation to valve; valves on nozzles open automatically
Brush Electrical Engrg. Co.	....	....	Rotary pump	Steam relay system, pulsating action
Erste Brünner M. F. G.	50	40-50	Double rotary valveless pump	Hartung type governor, steam relay and piston valve on main inlet; pulsating governing
Franco Tosi.	....	55-90	Rotary gear pump	Hartung type governor, oil relay system on main valve, automatic oil relay nozzle governing
Gebrüder Sulzer.	....	....	Triple gear pump	Automatic hydraulic regulator, centrifugal pump on oil only; throttling of supply; oil relay on all gear; no mechanical governor
Melms & Pfenninger, Breitfeld, Danek & Co.	40-80	35-85	Eccentric rotary pump	Hartung type oil relay, throttling governor
Allis-Chalmers Co.	50-60	60-140	Rotary lobe pump, auxiliary duplex pump for starting	Hartung type oil relay, throttling governor
Allegemeine Electricitäts Gesellschaft.	50-70	100-125	Rotary gear	Hartung type oil relay, governor throttling steam; also automatic nozzle control

Maschinenfabrik Augsburg. Nurnberg.	....	45-70	Horizontal rotary gear	Hartung type oil relay, governor throttling steam; also automatic steam control on nozzle valves
British Westinghouse Co.	....	....	Rotary gear pump	Heavy Hartung type governor direct-connected to throttling valve
Bergmann Electricitäts Werke.	....	....	Rotary gear pump	Hartung type governor throttling steam; nozzle valves opened by hand
Belliss & Morcom.	40-50	As high as 90	Double-acting valveless pump, 80-100 r.p.m.	Centrifugal governor, oil relay simply throttling steam supply
Escher. Wyss & Co.	....	....	Gear pumps, 1 for relay, 1 for bearing oils	Hartung type, oil relay simple throttling governor
Maschinenfabrik Oerlikon.	Not exceeding 66	Not exceeding 75	Rotary gear pump	Hartung type, oil relay governor, throttling steam supply; main throttle valve also opened by oil relay
Sachsische Maschinenfabrik.	....	....	Rotary type	Oil relay governor
Frazer & Chalmers.	....	....	....	....
Pokorny & Wittekind.	50-80	30-50	....	Oil relay governor
General Electric Co.	....	....	Rotary gear pumps	Vertical centrifugal governor operating oil relay which controls nozzles; nozzle governing
British Thomson Houston Co.	50-60	50-70	Rotary pump	Same as General Electric Co.

TABLE 1—*Continued*

Manufacturer	Oil Data	Type of Glands	Provision for Overspeed Regulation
C. A. Parsons & Co.	....	Steam-packed labyrinth at shaft	....
Westinghouse Mach. Co.	Oil pressure on bearings 3 to 4 lb., relay pressure 60 lb.	Water-packed glands with centrifugal impeller	Emergency governor to shut off steam at about 12% overspeed
Willans & Robinson.	Bearing pressure about 10 lb.	Steam-packed labyrinth	Emergency governor for overspeed
Brown Boveri & Co., Richardsons Westgarth & Co.	....	Steam-packed labyrinth	Emergency governor closes spring controlled throttle valve
Brush Electrical Engrg. Co.	....	Steam-packed labyrinth; water-packed glands also used	Emergency oil relay control on throttle valve
Erste Brünner M. F. G.	7-10 lb. on bearing	Steam-packed labyrinth	Emergency governor to close sprin_ loaded throttle valve
Franco Tosi.	10.4 gal. per min. pumped on 300 kw.; 18.4 gal. per min. on 12.000 kw.	Steam-packed labyrinth; water-packed glands also used	Emergency oil relay governor to close main throttle valve at 15% overspeed unique device
Gebrüder Sulzer.	Bearing oil pressure 20 lb.	Steam-packed labyrinth; labyrinth packing consists of large number thin sheets placed radial. with close clearance on shaft	Oil relay control on steam inlet valve
Melms & Pfenninger. Breitfeld. Danek & Co.	Oil temperature at bearing 105 to 120° F.	Steam-packed labyrinth; exhaust end packing adjustable.	Emergency valve to operate at from 10-15 per cent overspeed
Allis-Chalmers Co.	Bearing pressure 5 lb., relay pressure 30 lb., bearing oil temperature 110° F. best; large quantities pumped	Water-packed glands with centrifugal impeller	Emergency governor to close spring-loaded throttle valve

Allegemeine Electricitäts Gesellschaft.	Oil temperatures at bearings from 175 to 190° F.	Steam-packed labyrinth and carbon rings	Emergency governor to close spring-loaded throttle valve
Maschinenfabrik Augsburg, Nurnberg.	....	Graphite rings in glands, steam-packed	Emergency governor
British Westinghouse Co.	....	High-pressure end, labyrinth and water gland; low-pressure end, water gland with centrifugal impeller	Emergency governor closes spring actuated safety valve on steam inlet
Bergmann Electricitäts Werke.	Relay pressure 30 lb.	Steam-packed labyrinth	Emergency governor to close throttle at 10% overspeed
Belliss & Morcom.	Relay pressure 40 lb.; estimate 10 per cent of heat losses to go through oil, design oil pump accordingly	Multi-cellular with carbon rings and steam packed	Emergency governor controls oil relay to shut off steam
Escher, Wyss & Co.	....	High-pressure end, carbon ring packing; low-pressure, labyrinth	Emergency governor to operate at 8-10% overspeed
Maschinenfabrik Oerlikon.	Oil usually required is 0.02 gal. per kw-min.	High-pressure, graphite; low-pressure, steam-packed labyrinth	Emergency governor closes main throttle valve through oil relay
Sachsische Maschinenfabrik.	....	High-pressure, carbon; low-pressure, steam-packed labyrinth	Emergency governor to operate at 15% overspeed
Frazer & Chalmers.	....	High-pressure, metal rings and labyrinth; low-pressure, labyrinth	....
Pokorny & Wittekind.	From 8-18 gal. per min. circulated according to size	High-pressure, carbon rings and labyrinth; low-pressure, labyrinth	....
General Electric Co.	Relay pressure about 70 lb., bearing pressure 25 lb.	Carbon ring packing on both ends	Emergency governor to close unbalanced throttle valve
British Thomson Houston Co.	½ gal per min. per bearing on 1000 kw. units; 1½ gal. on 5000 kw. unit; same amounts to thrust	Carbon ring packing	Emergency governor to close throttle valve at 15% overspeed

TABLE 1—*Continued*

Manufacturer	Type of Coupling	Additional Notes
C. A. Parsons & Co.	Flexible claw	Simple Parsons turbines, usually very long spindles; large sizes in 2 cylinders
Westinghouse Mach. Co.	Flexible claw	Small sizes simple Parsons; large sizes Curtis-Parsons, double flow in low-pressure, heavy thrust block to take any end thrust
Willans & Robinson.	Flexible claw	....
Brown Boveri & Co., Richardsons Westgarth & Co.	Flexible claw	Effect on steam consumption of changes in (*a*) vacuum, 5-6% per 1 in. vacuum; (*b*) steam pressure, 1% per 15 lb.; (*c*) superheat, 1% per 11° F.
Brush Electrical Engrg. Co.	Flexible claw	....
Erste Brünner M. F. G.	Flexible claw	
Franco Tosi.	Flexible claw	Effect on steam consumptiou of changes in (*a*) vacuum, 7% per 1 in. at 28 in.; (*b*) steam pressure, 1% per 15 lb.; (*c*) superheat, 1% per 12.5° F.; large thrust block in form revolving piston, labyrinth packings; oil admitted both sides, movement shaft opens one side, closes other, making pressures on both different, automatically compensating for end thrust
Gebrüder Sulzer.	Special design of flexible coupling	End thrust all taken up by automatic oil controlled balance piston on end of shaft similar to Franco Tosi's
Melms & Pfenninger, Breitfeld, Danek & Co.	Flexible claw	Effect on steam consumption of changes in (*a*) vacuum 28-29 in., 5%; 27-28 in., 4%; 26-27 in., 3.5%; (*b*) steam pressure 1% per 12 lb.; (*c*) superheat 1% per 10° F.
Allis-Chalmers Co.	Flexible claw	....

Allegemeine Electricitäts Gesellschaft.	Solid	......
Maschinenfabrik Augsburg, Nurnberg.	Solid	......
British Westinghouse Co.	Flexible claw	......
Bergmann Electricitäts Werke.	Solid	......
Belliss & Morcom.	Special design of flexible coupling	Flood bearings with great quantity of oil to flush away heat rapidly
Escher. Wyss & Co.	Solid	......
Maschinenfabrik Oerlikon.	Flexible with leather disks	Blade angles, 20 deg. on stationary blades, 30 deg. on moving blades
Sachsische Maschinenfabrik.	Flexible with leather disks	......
Frazer & Chalmers.	......	......
Pokorny & Wittekind.	Solid	Practically all turbines built for connection to turbo-compressors; effect on steam consumption of changes in (*a*) vacuum live-steam turbines. 5% per in., exhaust steam turbines 10% per in. vacuum; (*b*) steam pressure, 1% per 25 lb.; (*c*) superheat 1% per 12° F.
General Electric Co.	Solid	......
British Thomson Houston Co.	Solid	Effect on steam consumption of changes in (*a*) vacuum 7% increase per in. above 28 in., 150 lb. steam gage, 8% decrease per in. below 28 in., 150 lb. steam gage; (*b*) steam pressure 1% per 10 lb. around 150 lb. pressure; (*c*) superheat 1% per 10° F.

to compare results, for it is largely dependent on conditions beyond the control of the turbine builder. For instance, if the plant does not contain superheaters, the b.t.u. per kw-hr. will be high. The same will be true of a plant which has a warm cooling-water supply for condensers and consequently carries low vacuum. Yet the turbines may be designed to give a high efficiency ratio under these conditions. In fact, they may be able to utilize the heat available more efficiently than the turbines in another plant with both high superheat and high vacuum.

70 This can be seen in Table 2, in which recent turbine tests have been tabulated. The Brown-Boveri turbine at the Dunstan power plant uses 14,980 b.t.u. per kw-hr. with an efficiency ratio of 68.8 per cent. Yet the Westinghouse City Electric with a lower steam pressure, lower superheat and lower vacuum, has an efficiency ratio of 68.9 per cent, though using 16,925 b.t.u. per kw-hr. The Erste Brünner Vienna turbine requires 16,460 b.t.u. per kw-hr. with 71.8 per cent efficiency ratio. It is therefore apparent that the efficiency ratio alone will express in the best manner the degree to which the designer has approached ideal results in his turbine.

71 The test results in Table 2 were grouped in order to analyze the relative merits of the different types of turbines on the basis of efficiency ratios. The Curtis-Parsons machines built by Erste Brünner hold first place in the list, but are followed closely by others of the same type built by Brown Boveri and Westinghouse Machine Company. The Parsons turbines built by Allis-Chalmers and Brown Boveri also show high efficiencies. The second class in the order of efficiency includes turbines of the Curtis-Rateau and Curtis-Zoelly types, among which the turbines of the A. E. G. and British Westinghouse Company show remarkably good results. The next group includes simple Zoelly and Rateau turbines. The last group comprises straight Curtis types.

72 The superiority of the Curtis-Parsons over the Parsons type is probably due to the reduction in the fluid friction and rotational losses occurring in the first cylinder of the Parsons by the use of a Curtis stage in this section.

73 The Parsons low-pressure sections evidently utilize the heat in the steam only slightly more efficiently than do the impulse turbines. The great surface areas of all disk type turbines which must be whirled in steam, produces losses which are apparently somewhat larger than the combined whirling losses and leakage in the Parsons

drum turbines. Both the Zoelly and Curtis-Rateau types appear to use the steam more effectively in the low-pressure sections than the Curtis alone. Many European engineers hold the opinion that where high economy is to be obtained, the impulse turbine of the Rateau or Zoelly type is superior to the Curtis, though its manufacturing costs are higher. The Curtis-Rateau construction has all the commendable features of impulse turbines and has proved very economical.

74 The results shown in Table 2 are from the best reliable tests that have been made on each type. Objection may be raised that these results do not represent actual operating conditions as under varying loads, nor the average economy of any type of turbine. For instance, the Curtis turbine usually gives a very flat water-rate curve, while the Parsons type is more convex. On the other hand, recent tests on the new Curtis-Parsons types have also shown flat water-rate curves at various loads. It was impossible to compare the various types from this standpoint on account of absence of complete data of such tests.

75 It is interesting to note in Table 2 that the best results have been obtained within the past two years and that these show a considerable increase in efficiency over the earlier turbines.

LOW AND MIXED-PRESSURE TURBINES

76 One of the first low-pressure turbines installed was described by Professor Rateau in his paper on Different Applications of Steam Turbines.[1] The exhaust steam from various non-condensing reciprocating engines around mines was conducted to a regenerator, from which the turbine drew its steam supply.

77 Many low-pressure turbines have been erected since 1904 and have shown very economical results. In some installations it is usual to provide for operation on high-pressure steam when the supply of exhaust steam is insufficient to meet the power demand. Hence, the mixed pressure turbine has been developed. In Europe a Curtis stage is added at the inlet and the live steam passed through this before entering the low-pressure section. The whole of the heat content of the live steam can be effectively utilized by this method. Bleeder turbines are also being built, in which, after partial expansion to some fixed pressure, a portion of the steam is withdrawn from the casing for heating or industrial purposes.

[1] Trans. Am. Soc. M. E., vol. 25, p. 782.

TABLE 2 ECONOMY TESTS OF HIGH PRESSURE STEAM TURBINES

EFFICIENCY RATIOS BASED ON E.H.P. MARKS & DAVIS STEAM TABLES USED

Maker of Turbine	Type	Date of Test	Load-Kw.	R.p.m.	Steam Pressure Lb. Absolute	Temperature at Throttle, deg. fahr.	Vacuum referred to 29.92" Bar	Condenser Pressure, Lb. Absolute	Lbs. of Steam per Kw-Hr.	B.t.u. per Kw-Hr.	Heat Utilized per Lb. of Steam	Heat Available per Lb. of Steam	Efficiency Ratio	Reference
Erste Brünner M. F. G.	Curtis-Parsons	1910	2128	1500	156.2	482	27.89	0.995	13.82	16460	247.0	343.8	71.8	Periodische Mitteilungen
Erste Brünner M. F. G.	Curtis-Parsons		6000	960	184.9	573	28.18	0.854	12.56	15570	271.5	380.7	71.3	Zeit. D.V.D. Ing., 12/10/'10
Erste Brünner M. F. G.	Curtis-Parsons	1910	7442	960	192.0	584	28.18	0.853	12.625	15705	270.2	384.4	70.3	Periodische Mitteilungen
Westinghouse Machine Co.	Curtis-Parsons	1910	9173	1800	181.7	433	27.81	1.032	14.57	16925	234.1	340.2	68.9	Trans. A.S.M.E., vol. 32
Brown Boveri & Cie.	Curtis-Parsons		3053	1360	150.2	505	29.00	0.456	13.01	15990	262.2	385.5	68.0	Dinglers P.J., 6/17/'12
Erste Brünner M. F. G.	Curtis-Parsons	1910	1416	1260	128.2	482	27.60	1.137	15.18	18060	224.6	326.5	68.8	Periodische Mitteilungen
Brown Boveri & Cie.	Curtis-Parsons	1911	1750	1500	176.4	586	27.08	1.392	14.23	17500	239.5	354.8	67.5	Zeit. F.D.G. Turb., 5/30/'11
Brown Boveri & Cie.	Curtis-Parsons	1910	3764	1500	161.2	561	28.77	0.562	13.04	16290	261.5	391.4	66.8	Zeit. F.D.G. Turb., 5/30/'11
Westinghouse Machine Co.	Curtis-Parsons		9830	750	192.2	475	27.22	1.322	15.15	17790	225.2	336.0	67.0	Trans. A.S.M.E., vol. 32
Brown Boveri & Cie.	Curtis-Parsons	1911	1495	3000	200.6	563	26.41	1.720	14.78	17880	230.7	345.5	66.8	Data from Manufacturer
Brown Boveri & Cie.	Curtis-Parsons	1911	1271	3000	172.1	568	27.31	1.278	14.61	17880	233.5	354.3	65.9	Data from Manufacturer
Westinghouse Machine Co.	Curtis-Parsons		11466	750	191.7	484	28.07	0.910	14.45	17210	236.0	360.5	65.5	Trans. A.S.M.E., vol. 32
Erste Brünner M. F. G.	Curtis-Parsons		1250	3000	184.9	573	27.89	0.996	14.32	17680	238.2	373.1	63.9	Zeit. D.V.D. Ing., 12/10/'10
Brown Boveri & Cie.	Curtis-Parsons	1910	3320	1500	180.9	525	29.02	0.440	13.50	16680	252.7	401.3	63.0	Zeit. F.D.G. Turb., 5/30/'11
Brown Boveri & Cie.	Curtis-Parsons		5128	1000	171.2	565	28.52	0.726	14.35	17830	237.7	382.9	62.1	Stodola, 4th ed., p. 449
Breitfield, Danek & Co.	Impulse-Parsons	1909	3585	896	160.7	457	28.32	0.782	16.08	19070	212.0	352.4	60.2	Zeit. D.V.D. Ing., 12/10/'10
Brown, Boveri & Cie.	Parsons	1910	6257	1210	203.7	559	29.02	0.440	11.95	14980	285.5	415.0	68.8	Official Test Report
Allis-Chalmers	Parsons	1908	4300	1800	186.4	484	27.96	0.960	14.02	16690	243.4	355.7	68.4	Sibley Jour. of Eng., 1/11'
Brown Boveri & Cie.	Parsons	1903	3500	1360	156.4	499	28.84	0.532	13.71	16720	248.5	378.6	65.6	Zeit. D.V.D. Ing., 12/10/'10
Brown Boveri & Cie.	Parsons		3000	1360	165.0	625	27.02	1.420	14.75	18433	231.3	359.5	64.3	Die Turbine, 6/20/'11
C. A. Parsons & Co.	Parsons		5164	1200	214.3	509	28.95	0.473	13.18	16140	258.7	402.3	64.3	Stodola, 4th ed., p. 439
Allis-Chalmers	Parsons	1911	3850	1800	164.7	491	27.91	0.983	15.40	18410	221.3	348.3	63.5	Power, 1/2/'12
A. E. G.	Curtis-Rateau	1911	6518	1220	198.7	601	29.28	0.352	11.43	14640	298.4	434.2	68.7	Official Test Report
A. E. G.	Curtis-Rateau	1911	6565	1220	200.2	597	29.18	0.406	11.64	14848	293.0	427.7	68.5	Official Test Report

British Westinghouse......	Curtis-Rateau	1911	5066	1500	190.2	552	28.68	0.649	13.00	16100	262.4	391.5	67.0	Electrical Review, 6/23/'11
M. A. N................	Curtis-Zoelly		3584	1500	178.3	569	27.54	1.166	13.99	17190	243.7	361.3	67.5	Data from Manufacturer
Bergmann..............	Curtis-Rateau	1909	1545	1500	188.5	581	28.59	0.654	12.97	16230	263.0	396.3	66.4	Zeit. D.V.D. Ing., 12/10/'10
Bergmann..............	Curtis-Rateau	1910	2477	1500	140.0	522	28.81	0.588	13.93	17135	244.8	373.4	65.6	Elec. Zeit., 4/20/'11
A. E. G................	Curtis-Rateau	1908	4239	1500	188.3	662	29.11	0.397	11.97	15620	284.9	439.0	64.9	Stodola, 4th ed., p. 404
British Westinghouse......	Curtis-Rateau	1911	2930	1500	210.2	568	28.18	0.894	13.72	16935	248.7	383.3	64.9	Electrical Review, 4/28/'11
A. E. G................	Curtis-Rateau	1907	3169	1500	184.7	592	29.11	0.397	12.74	16230	267.7	425.1	63.0	Trans. A.S.M.E., vol. 32
M. A. N................	Curtis-Zoelly		2507	1500	175.5	460	27.40	1.234	16.24	19020	210.0	334.6	62.8	Data from Manufacturer
Bergmann..............	Curtis-Rateau	1909	1562	1500	186.8	555	28.33	0.780	14.57	17970	234.1	381.3	61.4	Data from Manufacturer
James Howden & Son.....	Zoelly	1909	6383	1000	202.7	520	27.33	1.269	14.305	17150	238.5	353.0	67.5	Engineer, London, 10/29/'09
M. A. N................	Zoelly	1910	1400	3000	180.7	554	27.40	1.237	14.21	17310	240.0	356.2	67.4	Zeit. D.V.D. Ing., 12/10/'10
Escher, Wyss & Co........	Zoelly	1910	2052	3000	193.9	585	28.39	0.750	13.04	16290	261.5	392.6	66.6	Zeit. F.D.G. Turb., 2/20/'11
Escher, Wyss & Co........	Zoelly	1910	4189	1000	179.7	557	28.66	0.618	13.30	16520	256.5	391.3	65.5	Zeit. F.D.G. Turb., 2/20/'11
F. Ringhoffer............	Zoelly	1908	3000	1000	170.7	470	27.60	1.138	15.52	18278	219.8	339.2	64.8	Zeit. D.V.D. Ing., 12/10/'10
M. A. N................	Zoelly	1910	1250	3000	182.1	582	28.82	0.540	13.09	16500	260.2	404.5	64.4	Zeit. D.V.D. Ing., 12/10/'10
Oerlikon................	Rateau	1911	3166	1500	213.9	663	29.25	0.367	11.44	14970	298.2	450.6	66.1	Engineering, 10/20/'10
Escher, Wyss & Co........	Zoelly		5118	1000	133.7	549	27.55	1.161	15.18	18530	224.6	341.6	65.7	Dinglers P.J., 7/15/'11
Escher, Wyss & Co........	Zoelly	1908	5000	1000	166.4	539	26.38	1.736	16.13	19350	211.2	330.4	63.9	Zeit. D.V.D. Ing., 12/10/'10
Escher, Wyss & Co........	Zoelly		3540	1500	155.1	469	28.21	0.838	15.07	17940	226.3	349.5	64.8	Dinglers P.J., 7/15/'11
Escher, Wyss & Co........	Zoelly	1910	1641	3000	221.0	672	27.91	0.985	13.08	16775	260.6	406.5	64.1	Zeit. F.D.G. Turb., 2/20/'11
Escher, Wyss & Co........	Zoelly	1910	1235	3000	176.8	451	28.39	0.750	15.35	18156	222.3	357.8	62.2	Zeit. F.D.G. Turb., 2/20/'11
British Thomson-Houston.	Curtis	1911	2987	1500	154.7	505	26.75	1.557	15.96	18960	213.7	321.2	66.5	Engineering, 10/20/'11
Gen. Elec. Co............	Curtis		3464		210.0	513	28.75	0.575	13.62	16620	250.4	393.4	63.6	Trans. A.S.M.E., vol. 32
British Thomson-Houston.	Curtis	1909	2500	1500	126.5	414	28.47	0.711	15.92	18590	214.0	336.1	63.7	Zeit. D.V.D. Ing., 12/10/'10
A. E. G................	Curtis	1906	3000	1500	191.3	590	29.05	0.427	12.79	16240	266.6	420.4	63.4	Zeit. D.V.D. Ing., 12/10/'10
A. E. G................	Curtis	1909	2236	1500	191.6	654	29.34	0.284	11.77	15450	289.8	455.8	63.6	Zeit. D.V.D. Ing., 12/10/'10
Gen. Elec. Co............	Curtis		8880		192.5	487	28.02	0.933	15.05	17965	226.7	359.5	63.1	Trans. A.S.M.E., vol. 32
British Thomson-Houston.	Curtis	1911	1541	1500	149.7	365	27.97	0.956	17.46	19720	195.3	320.2	61.0	Engineering, 10/20/'11
Gen. Elec. Co............	Curtis		10816	750	190.0	525	29.39	0.260	12.90	16135	264.5	427.3	61.9	Trans. A.S.M.E., vol. 32
Gen. Elec. Co............	Curtis		5095		185.1	554	29.40	0.255	12.71	16090	268.4	436.0	61.6	Trans. A.S.M.E., vol. 32
British Thomson-Houston.	Curtis	1911	1221	3000	134.7	448	27.16	1.353	17.75	20690	192.2	314.0	61.2	Engineering, 10/20/'11
Gen. Elec. Co............	Curtis	1910	8775	750	194.0	451	27.95	0.956	15.95	18720	213.8	350.8	61.0	Trans. A.S.M.E., vol. 32

References: Zeit. D.V.D. Ing.—Zeitschrift des Vereines Deutscher Ingenieure; Zeit. F.D.G. Turb.—Zeitschrift für das Gesamte Turbinenwesen; Dinglers P.J.—Dinglers Polytechnisches Journal; Elec. Zeit.—Electrotechnische Zeitschrift.

78 Low-pressure turbines are frequently installed to use the exhaust steam of reciprocating engines without regenerators. In this case the generators are sometimes tied together electrically and the turbines are only fitted with an overspeed governor. Messrs. Stott and Pigott showed the results that could be obtained from such a combination in their paper, Test of a 15,000-Kw. Steam-Engine-Turbine Unit.[1] Such turbines are usually installed in stationary work, only when the reciprocating engines are already in service. The high-pressure turbine in a new plant requires less floor space, has less complicated machinery, is cheaper in first cost and in maintenance, and approaches, if it does not equal, the economy to be derived from the combination unit in every-day service. Nevertheless, there have been a number of combined engine and turbine plants recently installed in England which have proved very satisfactory.

79 It is probable that low-pressure turbines will be installed in the near future in large gas engine stations to utilize the waste heat in the gas engine exhausts.

TURBO-COMPRESSORS

80 Turbo-compressors have some decided advantages over reciprocating compressors, such as smaller floor space, absence of inlet and discharge valves, low cost of upkeep and no internal lubrication. They are being manufactured quite extensively in Europe and have been introduced in America by the General Electric Company, one of whose turbines was described by Mr. R. H. Rice in his paper, Commercial Application of the Turbine Turbo-Compressor,[2] read at the Pittsburgh meeting of the Society.

81 Turbo-compressors are built either with curved or radial impeller blades which discharge the air into smooth expanding diffusor channels to convert the velocity energy of the current into pressure. Usually guides are provided to direct the air into the entrance of the next stage without eddies. All passages are made as smooth as possible with no abrupt bends or turns, and all walls are water-cooled. The air is prevented from leaking back from stage to stage by labyrinth packings such as are used in impulse turbines.

82 European builders have installed turbines to deliver air at as high pressures as 130 lb. per sq. in. gage and are prepared to furnish them up to 180 lb. discharge pressure.

[1] Trans. Am. Soc. M. E., vol. 32, p. 69.

[2] The Journal Am. Soc. M. E., March 1911, p. 301.

83 Turbo-blowers have also been built to deliver large volumes of air at low pressure, such as are required in furnace work. These units have no water-cooled jackets. The first difficult problem encountered in the construction of turbo-blowers or compressors was the provision of a suitable governing device for the unit. However, several ingenious and satisfactory arrangements have recently been developed and it is probable that this difficulty will soon be overcome completely.

84 The efficiency of turbo-compressors with water-cooling is defined as the ratio of the power required to compress the given quantity of gas isothermally to the power consumed at the compressor coupling in the actual compression. This efficiency in well designed units with discharge pressures between 60 and 150 lb. should fall within the limits of 60 and 70 per cent. The best results noted up to the present time were obtained on a turbo-compressor built by Pokorny and Wittekind for the Victoria Falls Power Company in South Africa, which on official test showed an efficiency of 67.7 per cent.

85 When there is no water-cooling provided, the efficiency of a turbo-blower is expressed as the ratio of the power required to compress the given quantity of air adiabatically to the power actually expended at the compressor coupling. This efficiency, depending on the size of the blower, should fall between 70 and 80 per cent as a maximum. An efficiency of 78 per cent has been obtained on official tests of a Rateau turbo-blower built by Kuhnle, Kopp and Kausch and is probably the best result obtained up to the present time on this type of compressor.

86 It can thus be seen that in so far as efficiency is concerned, the turbo-compressor is equal to the average reciprocating compressor. It seems probable that turbo-compressors and blowers will be used to an increasing extent, largely on account of their low first cost and operating costs as compared with steam reciprocating units.

87 The high thermal efficiency of the gas-driven blowing engine exceeds that possible in a turbo-compressor unit, so that the former will continue to be used in blast-furnace work.

TURBO-DRIVEN PUMPS

88 The steam turbine is an ideal source of power to drive centrifugal pumps, especially when it is necessary to lift against high heads. Hence it has been installed in several places for city fire service, using lake or river water in high-pressure mains. The

efficiency of such centrifugal pumps usually ranges from 65 to 80 per cent, so that, in spite of the high efficiency of the turbine itself, the combined set will not give as good economy as a high grade reciprocating pumping engine. However, its first cost is low, it requires no internal lubrication, takes up very little floor space, and has no valves to require examination or renewals.

GEARED TURBINES

89 Attempts have been made to adopt steam turbines for direct connection to continuous current generators and other slow-speed machinery. A steam turbine to be economical must be a high-speed machine, and hence its use with slow-speed machinery has not proved entirely satisfactory. Dr. De Laval adopted spur gearing as a means of reducing speeds on his first simple impulse turbines, and builders of this type still use this construction. It is only within the last few years that attempts have been made to apply gearing as a means of speed reduction on other types of turbines. The Westinghouse Machine Company are now manufacturing direct-current turbo-generators with the Melville-MacAlpine reduction gearing between turbine and generator. This gear is also being built for use in marine work to drive slow-speed propellers. The gear wheels in this construction are carried on a floating frame so that the teeth may be always in correct alignment. One set of such gearing showed under test an efficiency of 98.5 per cent.

90 C. A. Parsons & Co. have built several notable reduction gears for steam turbines, in which the floating frame idea was omitted. A mixed pressure steam turbine of 750 b.h.p. is now in use driving a three high set of rolls through gearing at the Calderbank Steel Works near Glasgow, Scotland. A flywheel is placed on the same shaft as the driven gear and thus takes the shock off the turbine when a billet enters the rolls. In 1909 the Parsons Marine Steam Turbine Company installed a geared turbine of 1000 h.p. in the S. S. Vespasian of 4000 tons. Extensive experiments were carried out and it was found that the efficiency of this gearing, which had no floating frame, ranged between 98 and 99 per cent. After a year's operation, in which the ship covered 20,000 miles, tests were again made on the gearing with equally good results. On examination no appreciable signs of wear could be noted on the gear teeth, which were made of mild chrome nickel steel and were flooded with oil.

91 It is perfectly feasible to adopt the steam turbine through gearing to belt and rope drives when these are required in large powers. Under certain conditions, where fuel costs are high and water for condensation is plentiful, such an installation would prove an economical investment in place of reciprocating engines. The direct turbine drive would then come into competition with the motor drive. The losses in lineshafting can be greatly reduced by the use of ball or roller bearings so that the turbine drive may prove very economical in some instances as compared with individual motor drives.

92 The use of geared turbines in large sizes has been in the nature of an experiment until quite recently. Judging from the results obtained in recent installations, their commercial success seems now assured. In the design of these units the tendency will be to simplify details. The success of the Parsons gears on the S. S. Vespasian should encourage designers to do away with any special devices to secure alignment and to provide simply accurately cut gears properly meshed and running in a flood of oil.

MARINE TURBINES

93 All the standard types of turbines have now been adopted for marine service in driving screw propellers, either direct-connected or through gearing. The design of direct-connected turbines is complicated by the fact that the speed of screw propellers must necessarily be low as compared with the most favorable speeds for economical steam-turbine operation. Hence these turbines require large spindle diameters and massive construction and yield correspondingly poor steam economies, especially at slow speeds. These units are usually built with the power divided between two or more shafts connected to high and low-pressure cylinders. With geared equipments the turbines can be operated at their most efficient speeds, while the gears can be so designed that the propeller also runs at its most economical speed.

94 Reversing is made possible by suitable blading in the low-pressure ends of the main units into which live steam is admitted when desired. When the turbine is running forward, this blading revolves in vacuum and consumes but little power.

95 Combined types of turbines are also being introduced in marine installations. A recent Curtis design includes a drum impulse section. M. Zoelly now uses Curtis stages in his high-pressure section, but with steam velocities not exceeding 1300 ft. per sec.,

obtained by converging nozzles only, and drum impulse construction on the low-pressure ends. Several other European builders have also used Curtis stages in the high-pressure portion.

96 Reciprocating engines exhausting into low-pressure turbines have been installed in several ships, the most notable of which is the Olympic, and have shown very satisfactory results. In this case the engines are used for reversing.

97 Many schemes have been proposed to install turbo-generators of central station type on shipboard and to operate the propeller shafts by means of large slow-speed induction motors. Marine engineers object to this arrangement on account of the dangers accompanying the use of such electrical machinery and auxiliaries in marine service. This objection seems to be due largely to inexperience with electrical machinery, as the essential conditions of operation in marine work do not differ greatly from those under which many electrical machines operate satisfactorily in land practice.

98 Turbo-driven lighting sets and other auxiliaries are being used in increasing numbers on shipboard, owing largely to the high efficiencies which may be obtained, to the small floor space required, and to the light weight of the units.

99 Recent orders for turbine-driven steamships abroad include some interesting equipments. The Canadian Pacific Railway has ordered two boats with four screws and with Parsons turbines. The two outside screws will have high and intermediate pressure turbines respectively, while the two center screws will be connected to low-pressure turbines. Two twin-screw passenger boats of 5000 h.p. with Parsons turbines have been ordered for the Southampton-Havre service. Each set consists of a high-pressure and a low-pressure turbine geared individually to its own propeller shaft. The British Government has ordered two twin-screw destroyers also to use Parsons geared turbines, totalling 14,000 h.p. per ship, or 7000 h.p. per gear. The United States Government has placed an order with the Westinghouse Machine Company for a gear equipment on one of its colliers.

100 Geared turbine equipments are thus making rapid headway on account of the high efficiency of the combination and the resultant favorable steam consumption obtained.

101 At the present time about 90 per cent of the marine turbines built have been of the Parsons type. Here again the inefficiency of the Parsons high-pressure sections has become apparent, so that it is probable that a construction similar to Zoelly's high-pressure end

will be introduced in this section. Sir Charles A. Parsons is quoted as saying: "In the low-pressure blades of the Mauretania the leakage was practically nothing and their efficiency was about 85 per cent." [1] Under such conditions it does not seem probable that much higher efficiency can be obtained by use of other constructions than the Parsons reaction type in the low-pressure section. It is reported that the low-pressure blading of Parsons turbines in ships of the United States Navy has given considerable trouble, and also that the turbines need more careful handling when starting up than do impulse turbines.

TREND OF TURBINE DEVELOPMENT

102 The cost of manufacture is a very important item in determining the future development of the steam turbine. Types such as the original Parsons and the Rateau, while inherently of very high efficiency, have too high manufacturing costs to compete with the newer combined types.

103 The writer offers as his opinion that the combined types, such as the Curtis-Parsons, the Curtis-Rateau and also the Curtis-Rateau-Parsons, previously described, will very soon supersede the simple types. It is probable that the Curtis turbine will eventually be built only in horizontal units and will gradually be modified to a Rateau or even a drum impulse construction in the low-pressure sections. The freedom from close adjustment in impulse turbines and the recent improvements in blading materials will greatly increase the use of this type, although Curtis-Parsons turbines are said to be cheaper to manufacture. In actual operation, it is an open question among engineers whether the reaction turbine has a higher commercial efficiency than the impulse type, and hence buyers usually consider first cost and personal preference only.

104 Turbines will probably be made shorter with very stiff shafts. With this construction many of the earlier blading troubles will disappear. But the peripheral speeds will also be increased and this will involve the development of suitable blading material and methods of holding blades that will satisfy these new requirements. Recent results seem to indicate that improved efficiency may be looked for with increased blade speeds.

105 Several impulse turbines have been built recently in Europe where the expansion was not complete in the nozzle, so that a portion of the expansion took place in the first moving blades. Some

[1] Engineering, Oct. 27, 1911.

large Curtis turbines recently installed in America are said to have Parsons blading in the last stage. These developments would indicate a movement to introduce reaction principles in impulse turbines, and further illustrate the tendency to merge types.

106 The hope of further improvement in efficiency lies in extensive study, particularly of the action of the steam during its passage through the moving and stationary blades, of the effect of form of blades, passages and casings and of various forms of baffles and balance pistons to prevent leakage. Such research work has not been carried out up to the present time by most manufacturers, largely on account of the extreme care and heavy expense involved in such tests. The present state of development has been largely one of cut and try. The increasing competition of the gas engine and the possible development of a satisfactory gas turbine will force manufacturers to develop their turbines to the greatest degree of economy.

107 With regard to detail, simplicity will be the leading consideration. With the introduction of Curtis high-pressure stages, nozzle governing will undoubtedly be used to an increasing extent, though the results obtained by Westinghouse, by Zoelly, and by Bergmann with simple throttling governors, raise a question as to whether the additional complication of nozzle governing will pay. Oil relays will probably replace all other systems of governing on account of their simplicity and reliability. The simple and efficient centrifugal oil pump governor of Sulzer appears to be an improvement of considerable moment, and will probably receive extensive use.

108 With the development of suitable gearing for steam turbines, their field of application has been greatly increased and turbines will shortly be used for purposes which engineers today would consider them utterly unfit. Low-pressure turbines will continue to be installed in plants where reciprocating engines are still in operation and also where large quantities of waste heat are available. The low and mixed pressure types of turbines will find a very extended use in connection with heating systems, evaporators, etc.

109 The development of the past ten years has been truly marvellous. No great gain in thermal efficiency seems possible, so that future improvements will be largely along the line of detail construction and modification.

110 The addresses of the firms referred to in Table 1 are as follows: C. A.

Parsons & Co., Newcastle, England; Westinghouse Machine Co., East Pittsburgh, Pa.; Willans & Robinson, Rugby, England; Brown Boveri & Co., Baden, Switzerland; Richardsons Westgarth & Co., Hartlepool, England; Brush Electrical Engineering Co., Loughborough, England; Erste Brünner, Brünn, Austria; Franco Tosi, Legnano, Italy; Gebrüder Sulzer, Winterthur, Switzerland; Melms & Pfenninger, Munich, Germany; Breitfeld Danek & Co., Prague, Austria; Allis-Chalmers Co., Milwaukee, Wis.; Allegemeine Electricitäts Gesellschaft, Berlin, Germany; Maschinenfabrik Augsburg Nürnburg, Nürnburg, Germany; British Westinghouse Co., Manchester, England; Bergmann Electricitäts Werke, Berlin, Germany; Belliss & Morcom, Birmingham, England; Escher Wyss & Co., Zurich, Switzerland; Maschinenfabrik Oerlikon, Oerlikon, Switzerland; Sachsische Maschinenfabrik, Chemnitz, Germany; Frazer & Chalmers, Erith, England; Pokorny & Wittekind, Frankfort-Bockenheim, Germany; General Electric Co., Schenectady, N. Y.; British Thomson Houston Co., Rugby, England.

The writer wishes to express his thanks to manufacturers of steam turbines in America and in Europe, who liberally provided him with the information on which this paper is based, both during personal visits to their works and by correspondence.

PROBLEMS IN NATURAL GAS ENGINEERING

By Thos. R. Weymouth

ABSTRACT OF PAPER

In the production and transportation of natural gas many problems are encountered requiring special applications of engineering principles. It is the purpose of this paper to point out the most important of these and to outline the methods of solution. A brief discussion is given of the properties of natural gas, including a table of analyses of gases produced in the principal gas fields of the United States, together with a formula connecting the heating value of the natural gas with its specific gravity. This is followed by the development of the original formulae for the flow of gas in pipe lines, the power required for compression and the storage capacity of lines, and examples are worked out showing the general method of design of a transmission system.

PROBLEMS IN NATURAL GAS ENGINEERING

By Thos. R. Weymouth, Oil City, Pa.

Member of the Society

The extensive increase in the production and distribution of natural gas in recent years has given rise to engineering problems of more or less unique interest. For a considerable period after natural gas had become an important factor in industrial life it was handled almost entirely by rule of thumb methods, but with the advent of large compressing stations and the enforced realization that the gas supply is not by any means unlimited, the application of engineering principles became essential, not only to secure greater economy, but also to cope successfully with the growing complexity of the problems encountered. The object of this paper is to present the most important of these problems and to outline the methods used in solving them. First, however, it is believed that a brief account of the characteristics of natural gas as it is found in America, will not be out of place.

PROPERTIES OF NATURAL GAS

2 *Origin and Composition.* Natural gas and petroleum are closely related and it is generally believed that they were generated in the earth by one and the same process. What this process is, or may have been, is a question of pure speculation among scientists, two principal theories having been advanced to explain it, both based upon geological observations.

3 The first hypothesis, the so-called chemical, or inorganic theory, holds that the gas is constantly being formed by the action of water on the carbides of different metals in the far inner regions of the earth, thus producing the hydrocarbons forming the principal constituents of natural gas. These hydrocarbons are then forced outwards toward the earth's surface by the high pressures generated until they finally lodge in the porous rocks in which we now find them.

The American Society of Mechanical Engineers, 29 West 39th Street, New York. All papers are subject to revision.

4 The second, or organic theory, maintains that the hydrocarbons were formed by the partial decomposition under water, of animal or vegetable matter in the rock strata where the gas is now found.

5 There are many arguments in support of each theory, as it is known that hydrocarbons can be produced by either of the methods suggested. This being so, it seems reasonable to suppose that both agencies were at work and that each may claim its share of the credit for the production of the vast quantities of gas obtained throughout the world.

6 By whatever manner produced, however, the fact remains that hydrocarbons form the principal constituents of natural gas as found in America, although other gases are present in widely varying, but relatively small proportions.

7 The analyses of gases found in pools covering practically the whole productive area of the United States are given in Table 1, which was compiled from various sources, the principal of which were the reports of the Geological Surveys of West Virginia, Vol. 1-a, 1904, and of Kansas, Vol. 9. These reports give very complete discussions of the theories mentioned, and describe in detail what the author believes to be the most reliable analytical work done on natural gas, namely, that of Prof. F. C. Phillips on Pennsylvania Natural Gas, in 1887, and that of Cady and McFarland on the Gases of Kansas, in 1906.

8 The table shows what an apparent lack of uniformity exists in the constitution of natural gas from different fields; but the most noticeable feature is the great preponderance of hydrocarbons, especially of the methane, or paraffin series. This group has the general chemical formula C_nH_{2n+2}, its chief member being methane, or marsh gas (CH_4). Methane occurs in all natural gas in proportions varying from about 14 per cent up to 97 per cent. It possesses high heating value but has practically no illuminating properties.

9 The second member of the series, ethane (C_2H_6), occurs in percentages ranging from 0 up to 40 or more. This gas is of much higher fuel value than methane, is considerably heavier, and possesses greater illuminating properties. Thus the heating value, specific gravity, and illuminating value of the gas in which it occurs are all raised by the presence of ethane.

10 The higher members of this series, propane (C_3H_8) and butane (C_4H_{10}), are present in dry gas only in minute quantities, if at all, and they are consequently of small importance.

11 Of the olefine series, or so-called "illuminants," having the general formula C_nH_{2n}, the only member present in measureable quantity is the leading one of the group, ethylene (C_2H_4), and this only in a fraction of 1 per cent.

12 Carbon monoxide (CO) is occasionally reported, although in such small proportion as to add very little to the fuel value of the gas.

13 Hydrogen has been reported in many analyses of natural gas, but, as has been pointed out by Phillips, Cady and McFarland, these indications were probably due to erroneous deductions from experimental results, and it is extremely doubtful if free hydrogen is ever present.

14 Hydrogen sulphide (H_2S) is found in the natural gas from a few isolated areas, but is not at all general. Its presence is indicated by a distinctive odor. At most, it exists in but a small fraction of 1 per cent and is, therefore, relatively unimportant.

15 The above list comprises all the gases ever found in natural gas that contribute to its heating value, and it will be seen that the only ones of any practical importance are methane and ethane, the first two members of the paraffin series.

16 In addition to the above, there are always found a number of inert gases, chief of which is nitrogen (N), which ranges in proportion from less than 1 per cent to almost 83 per cent in the various gases shown in Table 1. The majority of natural gases, however, that exist in any considerable quantity, or come from any great depth, seldom exceed 10 per cent in nitrogen content, and usually range from 4 to 7 per cent. Nitrogen is a non-reactive, elementary gas that acts merely as a diluent of the natural gas, reducing its fuel value.

17 Next in importance is carbonic acid gas (CO_2), which is found in proportions ranging from 0 up to about 4 per cent. It acts in the same manner as nitrogen, by reducing the effective heating value of the gas.

18 Oxygen has frequently been reported in varying quantities, but the probability is that it is present in traces only, and that the apparent high percentages sometimes reported were due to the samples having become contaminated by air.

19 The work of Cady and McFarland has shown that in all probability the element helium is a constituent of nearly all natural gases, together with other members of the argon group. Helium was

TABLE 1 ANALYSES OF GASES FROM THE WHOLE PRODUCTIVE AREA OF THE UNITED STATES

Location (Kansas Gases)	Year	O_2	CO_2	C_2H_4	CO	CH_4	C_2H_6	CH_4 C_2H_6	H_2	H_2S	He	N_2	B.T.U. by Analysis	B.T.U. by Equation [4]	Specific Gravity
*Dexter	1905	0.20	0.00	.....	0.00	14.85	0.41	15.22	trace	.....	1.84	82.70	139.7	82.6	0.8935
*Dexter (Greenwell Well)	1906	0.10	0.00	0.00	0.00	14.33	1.06	15.39	trace	.....	1.64	82.87	245.5	89.6	0.8977
*Eureka, new field	1906	0.10	0.20	0.00	0.00	51.80	0.00	51.80	0.00	.....	1.50	46.40	465.0	427.6	0.7430
*Eureka, town supply	1906	0.50	0.20	0.00	0.00	51.40	0.00	51.40	0.00	.....	1.50	46.40	461.0	424.6	0.7451
*Fredonia	....	trace	0.61	0.12	0.00	82.25	0.00	82.25	0.00	.....	0.616	16.40	739.8	729.6	0.6253
*Elmdale	1906	0.30	0.15	0.55	0.00	78.60	7.71	86.31	0.00	.....	0.56	12.13	836.1	826.1	0.6441
*Moline	1906	0.00	0.54	.....	0.00	74.10	0.00	74.10	trace	.....	0.51	24.85	665.0	652.2	0.6599
Burlington	1906	0.00	0.00	0.20	0.00	85.50	3.20	88.70	0.00	.....	0.495	10.60	820.9	810.3	0.6113
New Albany	1906	0.00	0.20	0.25	0.00	89.10	0.00	89.10	0.12	.....	0.49	9.84	804.0	794.7	0.5944
*Lawrence, deep well	1906	trace	0.92	0.00	0.00	81.40	0.00	81.40	0.00	.....	0.46	17.22	730.0	723.9	0.6318
*Olathe	1906	trace	0.00	0.10	0.00	84.40	0.00	84.40	0.00	.....	0.40	15.10	758.5	746.2	0.6148
Garnett	1906	trace	0.20	0.16	0.00	94.30	0.36	94.66	0.00	.....	0.37	4.61	855.1	848.9	0.5748
*Eudora	....	0.31	0.62	0.00	0.00	88.60	0.00	88.60	0.00	.....	0.27	10.20	795.0	792.3	0.6021
Parsons (Wilson County Gas)	....	trace	0.72	0.00	0.00	91.90	3.37	95.27	0.00	.....	0.27	3.74	878.8	877.7	0.5902
Buffalo	1906	trace	0.00	0.00	0.11	96.20	0.78	96.98	0.18	.....	0.27	2.46	876.3	873.5	0.5656
Altoona	1906	0.00	0.92	0.00	0.00	92.00	2.85	94.85	0.00	.....	0.263	3.97	870.5	873.1	0.5911
*Augusta	1906	0.00	0.00	0.77	0.00	79.10	7.44	86.54	0.00	.....	0.25	12.44	840.0	831.4	0.6430
Chanute	1906	0.10	0.00	0.00	0.00	94.70	0.00	94.70	0.00	.....	0.24	4.96	850.0	844.7	0.5731
Moran	1906	0.20	0.30	0.35	0.20	92.00	0.00	92.00	0.39	.....	0.214	6.35	832.9	831.8	0.5829
Peru	1906	0.10	0.51	0.00	0.00	81.70	7.60	89.30	0.00	.....	0.19	9.39	854.2	852.5	0.6309
Iola	1906	0.23	0.00	0.00	0.00	94.50	0.00	94.50	trace	.....	0.183	5.08	848.0	843.9	0.5746
Lawrence pipe line, April 16	1906	trace	0.20	.....	0.00	98.06	0.00	98.06	trace	.....	0.17	1.57	880.0	878.3	0.5605
Pipe line, October 23	1905	0.12	0.00	.....	0.00	98.00	0.00	98.00	0.00	.....	......	1.88	879.0	879.0	0.5615
Pipe line, December 12	1906	0.24	1.94	0.00	0.00	94.30	0.75	95.05	0.00	.....	0.17	2.60	858.0	869.8	0.5868
Arkansas City	....	0.20	0.10	0.10	0.00	81.10	11.95	93.05	0.00	.....	0.159	6.39	920.0	915.8	0.6392
Blackwell, Okla	1906	0.00	0.00	0.61	0.00	83.40	10.31	93.71	0.33	.....	0.16	5.19	922.4	918.4	0.6247
Humboldt	1906	0.10	0.00	0.81	0.00	94.00	1.97	95.97	0.00	.....	0.14	5.19	887.3	880.8	0.5996
Iola	1906	0.40	0.70	0.00	0.30	91.50	0.00	91.50	0.00	.....	0.132	6.97	822.0	826.8	0.5917
Erie	1906	0.22	0.33	0.30	0.00	90.30	4.26	94.56	0.00	.....	0.13	4.45	882.3	881.8	0.5971
Bonner Springs	....	0.10	0.00	0.00	0.00	97.18	0.00	97.18	0.25	.....	0.104	2.36	871.7	870.4	0.5616
Altamont pipe line, Liberty and Coffeyville	....	0.00	0.92	0.61	0.00	95.70	0.00	95.70	0.00	.....	0.08	2.69	868.0	872.1	0.5751
Caney	....	0.15	0.81	0.10	0.00	92.40	0.00	92.40	0.00	.....	0.08	6.46	830.5	833.1	0.5886
Sheffield, Mo	....	0.20	0.83	0.50	0.10	92.90	0.00	92.90	0.00	.....	0.041	5.43	840.7	845.9	0.5869
Kansas City, Mo., 2416 Tracey Avenue	....	0.10	0.60	1.20	0.20	87.20	7.03	94.23	0.00	.....	0.013	3.65	912.2	917.8	0.6141
Paola	1906	0.40	0.70	0.00	0.00	98.00	0.00	98.00	0.00	.....	0.0093	0.88	879.0	884.7	0.5655
Topeka pipe line, December 22	1907	0.20	1.53	0.00	0.00	94.56	0.00	94.56	0.00	.....	......	3.71	849.0	858.1	0.5841
Lawrence pipe line, December 23	1907	trace	1.85	0.00	0.00	94.47	0.00	94.47	0.00	.....	......	3.68	848.0	859.6	0.5861
Gas from coal mine, Scranton, Pa	....	0.92	1.06	0.39	0.13	94.2	0.00	94.20	0.00	.....	trace	3.31	851.1	861.0	0.5842
Lawrence pipe line, July 11	1908	0.25	0.81	0.38	0.81	93.50	0.00	93.50	0.00	.....	......	4.25	847.2	877.6	0.5848
*W. Bloomfield, N. Y	1870	0.23	10.11	2.94	....	82.41	.....	.....	....	.....	4.31		782.3	855.6	0.6819

*Olean, N. Y.	1885	2.00	.....	1.00	0.50	96.50	.....	.....	....	.....	......	.. .	881.3	890.8	0.5703
Fredonia, N. Y.	1887	....	0.41	.....	....	46.43	43.62	90.05	....	.....	......	9.54	1102.5	1110.2	0.8078
Baldwinsville, N. Y., (Trenton)	1899	trace	.....	0.25	0.95	98.40	....	98.40	trace	.....	......	0.40	889.3	900.4	0.5596
Morgantown, W. Va. (Big Injun)	1904	0.20	0.006	0.40	0.40	80.94	14.60	95.54	trace	.....	......	3.46	965.4	969.1	0.6427
Fairmount, W. Va. (Bayard)	1904	0.20	0.100	0.20	0.40	81.60	14.09	95.69	0.20	.....	......	3.21	961.2	965.6	0.6379
Shinnston, W. Va. (Big Injun)	1904	0.20	0.000	0.40	0.40	79.95	15.09	95.04	0.00	.....	......	3.96	964.7	968.5	0.6469
Shinnston, W. Va. (Gordon)	1904	0.10	0.00	0.20	0.40	80.85	14.88	95.73	0.10	.....	......	3.47	966.7	969.6	0.6420
Lumberport, W. Va. (5th. sand)	1904	0.30	0.10	0.10	0.40	80.70	14.35	95.05	0.10	.....	......	3.95	955.8	958.6	0.6430
Shinnston, W. Va. (50 ft.)	1904	0.30	0.00	0.20	0.50	86.48	7.65	94.13	0.00	.....	......	4.87	902.0	905.9	0.6148
Sheffield, Pa	1887	trace	0.30	.....	....	70.55	20.09	90.64	....	.....	......	9.06	953.1	951.4	0.6908
Kane, Pa	1887	trace	0.20	.....	....	68.96	21.05	90.01	....	.....	......	9.79	954.0	950.6	0.6975
Wilcox, Pa	1887	trace	0.21	.....	....	72.64	17.74	90.38	....	.....	......	9.41	934.5	931.2	0.6803
Speechley, Pa	1887	trace	0.05	.....	....	67.89	27.55	95.44	....	.....	......	4.51	1048.0	1046.3	0.7057
Lyons Run, Murraysville, Pa	1887	trace	0.28	.....	....	97.60	0.10	97.70	....	.....	......	2.02	877.1	877.2	0.5647
Raccoon Creek, Pa	1887	trace	trace	.....	....	73.72	16.37	90.09	....	.....	......	9.91	922.0	918.9	0.6745
Baden, Pa	1887	trace	0.41	....	....	70.66	16.61	87.27	....	.....	......	12.32	885.5	882.4	0.6879
Houston, Pa	1887	trace	0.44	.....	....	65.71	18.55	84.26	....	.....	......	15.30	899.0	895.5	0.7109
Murraysville, Pa	1894	trace	0.20	.....	....	93.33	2.07	95.40	....	.....	......	4.40	870.0	868.7	0.5833
Pittsburg, Pa., (Exhibition Grounds)	1894	trace	0.52	.....	....	87.56	4.62	92.18	....	.....	......	7.30	859.1	860.1	0.6108
Creighton, Pa	1894	....	3.64	.....	....	86.87	9.49	96.36	....	.....	......	0.00	930.8	957.5	0.6340
Pittsburg, Pa. (Painter Well)	1894	....	0.40	.....	....	92.67	6.23	98.90	....	.....	......	0.70	930.9	933.7	0.5900
Allegheny City, Pa. (Salt Well)	1894	....	0.30	.....	....	87.53	5.07	92.60	....	.....	......	7.10	866.4	865.5	0.6101
Gambier, O	1875	0.80	0.30	.....	0.50	81.40	12.20	93.60	....	0.650	......	4.80	924.5	932.7	0.6414
Findlay, O	....	0.34	0.26	0.30	0.50	92.61	.....	92.61	2.18	0.20	......	3.61	844.1	851.7	0.5665
Thurston, O. (Clinton)	....	0.15	0.25	0.30	0.15	90.48	.....	90.48	0.55	.....	......	8.12	817.9	818.3	0.5894
Fostoria, O	....	0.35	0.20	0.20	0.55	92.84	.....	92.84	1.89	0.15	......	3.82	843.7	851.1	0.5678
Findlay, O	....	0.39	0.25	0.35	0.41	93.35	.....	93.35	1.64	0.20	......	3.41	849.6	856.2	0.5682
St. Marys, O	....	0.35	0.23	0.20	0.44	93.85	.....	93.85	1.74	0.21	......	2.98	852.0	859.7	0.5652
Cleveland, O	1894	....	0.20	.....	....	76.77	16.73	93.50	....	.....	......	6.30	955.6	953.5	0.6620
Butler, O	....	0.05	0.00	0.40	0.00	70.00	16.75	86.75	0.27	.....	0.15	12.38	901.6	895.0	0.6857
Muncie, Ind. (Trenton)	....	0.35	0.25	0.25	0.45	92.67	.....	92.67	2.35	0.15	......	3.53	844.5	850.9	0.5647
Anderson. Ind. (Trenton)	....	0.42	0.26	0.49	0.73	93.07	.....	93.07	1.86	0.15	......	3.02	850.5	860.7	0.5676
Kokomo, Ind. (Trenton)	....	0.30	0.29	0.30	0.55	94.16	.....	94.16	1.42	0.18	......	2.80	856.2	864.4	0.5668
Marion, Ind. (Trenton)	....	0.55	0.30	0.15	0.60	93.58	.....	93.58	1.20	0.20	......	3.42	848.6	858.8	0.5720
Marion. Ind. (Trenton)	....	0.00	0.73	0.86	0.00	77.40	14.18	91.58	0.00	.....	0.167	6.66	933.2	933.1	0.6592
Kokomo, Ind. (Trenton)	....	....	0.40	.....	....	88.91	4.69	93.60	....	.....	......	6.00	871.3	872.0	0.6046
Oregon	1904	....	2.40	.....	....	88.10	.....	88.10	....	.....	......	9.50	790.5	804.3	0.6159
*Fort Worth, Tex	1910	0.20	0.00	0.30	0.30	55.90	5.50	61.40	1.00	.....	......	36.80	596.8	585.6	0.7320
Point Albino, Canada	1896	....	trace	.....	....	85.83	10.74	96.57	....	0.74	......	2.69	945.8	953.2	0.6208
Vancouver, B. C	....	....	0.14	.. ..	....	.....	.....	93.56	....	.....	......	6.30	.....	.....	......
Bottineau, N. D	....	3.00	.....	0.20	1.20	82.70	.....	82.70	0.50	.....	......	12.40	750.2	763.4	0.6246
Kenova, W. Va	....	0.60	0.30	0.70	0.30	78.30	19.60	97.90	....	.....	......	0.20	1026.2	1036.8	0.6621
Kenova, W. Va	....	0.40	0.20	0.70	0.60	78.90	18.80	97.70	....	.....	......	0.40	1019.5	1029.2	0.6551

found in the Kansas gases in percentages as high as 1.8, and in only one case of all the gases tested was none found. Inasmuch as no effort was made to detect this gas in any former analyses, it is probable that it was present, although undetected, since it was usual to consider as nitrogen all residue left after determining the other gases present.

20 From the above it will be seen that while natural gas may contain a considerable number of constituent gases, the great bulk of it is composed principally of but four or five of any importance.

21 In Table 1 the gases marked with an asterisk are samples that came from small shallow wells, or were otherwise abnormal, and thus cannot be considered as representative. Excluding these from the list and striking an average of those remaining, the constitution of what may be termed the average natural gas, after slight modifications in accordance with the above discussion, would be about as in Table 2.

TABLE 2 CONSTITUTION OF THE AVERAGE NATURAL GAS

Methane (CH_4)	87.00
Ethane (C_2H_6)	6.50
Ethylene (C_2H_4)	0.20
Carbon monoxide (CO)	0.20
Hydrogen (H_2)	trace
Nitrogen (N_2)	5.50
Carbon dioxide (CO_2)	0.50
Helium (He)	0.10
Oxygen (O_2)	trace

B.t.u. per cu. ft. at 29.82 in. and 60 deg. = 887.3.
Specific gravity = 0.6135.

22 *Heating Value of Natural Gas.* The fuel value of natural gas depends principally upon the relative proportions present of methane, ethane, and the inert gases, such as nitrogen and carbon dioxide. The only satisfactory manner of ascertaining the heating value is by means of calorimetric determinations, but as very few of these were reported with the analyses shown in Table 1, and in order to arrive at some comparative idea of the relative fuel values of the various gases listed, column 14 is given, showing the b.t.u. per cu. ft. as computed from the analyses. In making calculations, the constants in Table 3 were used.

23 In the discussion of properties of gases it is necessary to refer all volumes to some definite standards of pressure and tem-

perature. The standards most used in scientific work are 29.92 in. (760 mm.) of mercury, corresponding to 14.7 lb. per sq. in. for the pressure base, and 32 deg. fahr. (0 deg. cent.) for that of the temperature, while in industrial work 30 in. of mercury and 60 deg. fahr. are largely used. Some years ago, F. H. Oliphant, geologist for the Standard Oil Company, published a handbook on natural gas, in which he established the pressure base of 14.65 lb. per sq. in. absolute, and temperature base of 60 deg. fahr., and since that time it has been customary for natural gas men to refer their measurements to these bases. A pressure of 14.65 lb. per sq. in. is 4 oz. above an average assumed atmospheric pressure of 14.4 lb., the latter being the average at about the elevation of the Great Lakes, which elevation was considered as fairly representing that of most of

TABLE 3 HEATING VALUE AND SPECIFIC GRAVITY OF THE GASES FOUND IN NATURAL GAS

Kind of Gas	Symbol	Net Heating Value, B.T.U. per Cu. Ft.	Specific Gravity Air = 1.0
Methane	CH_4	897	0.5529
Ethane	C_2H_6	1594	1.0368
Ethylene	C_2H_4	1471	0.9676
Carbon monoxide	CO	322	0.9671
Hydrogen	H_2	271	0.0692
Hydrogen sulphide	H_2S	615	1.1769
Nitrogen	N_2	....	0.9701
Carbon dioxide	CO_2	....	1.5195
Helium	He	....	0.1382
Oxygen	O_2	....	1.1052

the gas fields. Thus, 4-oz. gas is the generally accepted pressure unit of measurement among natural gas men and will be so considered throughout this paper. Frequently gas is bought or sold on different pressure bases, and in such cases the corresponding absolute pressures are determined by considering atmospheric pressure as being equal to 14.4 lb. per sq. in., as for instance, a 10-oz. selling base corresponds to $14.4+0.625=15.025$ lb. absolute.

24 Conforming with this usage, therefore, all formulae, heating values, etc., throughout this paper are given for the unit of measurement as being 1 cu. ft. at 60 deg. fahr. and 14.65 lb. per sq. in. absolute (29.82 in. of mercury), which is commonly referred to as "gas standard."

25 It will be noted in Table 1 that the heating values given are

the net or low values. In publishing gas analyses or constants, many writers, in fact, most of them, give the high values, but the author believes the low to be more rational, inasmuch as in nearly all uses to which natural gas is put as a fuel, it is impossible to recover the latent heat of vaporization of the steam formed by the combustion, and therefore the net heating values give a more truthful conception of the actual worth of the gas for fuel purposes.

26 When it is impossible to obtain a calorimetric determination of the heating value of a particular gas, the next best procedure is to compute it from the chemical analysis of the gas, using the values shown in Table 3 for the heating values of the constituent gases. This, of course, is done by multiplying the percentage of each gas present by its corresponding heating value per cubic foot, and adding the products. The specific gravity is obtained by computation in precisely the same manner. Such computed results are necessarily subject to whatever errors there may be in the analysis of the gas, and unless this has been done with great care and precision, a wide discrepancy may exist between the calculated and actual values.

27 It is oftentimes desirable to gain an approximate knowledge of the heating value of a gas when neither a calorimetric determination nor a chemical analysis is available. In such cases, a fair "guess" may be made from a determination of the specific gravity of the gas, provided it is known to be a normal "dry" gas without freakish tendencies. The specific gravity is readily determined by the effusion method, in which the time required to pass a given quantity of the gas through a pin-hole orifice in a thin plate under a given head, or pressure, is divided by the time required to pass the same quantity of air through the same orifice and under the same pressure; the square of the quotient being the specific gravity of the gas, referred to air. For most reliable results the air and the gas should be run at the same temperature, to avoid the necessity of a correction for this factor.

28 An approximate formula for determining the heating value from the specific gravity may be derived from the following considerations. In the analysis given in Par. 21 for an average natural gas, and which represents the average constitution of the gases considered as representative in Table 1, it will be seen that of the combustible gases, methane and ethane comprise 93.5 per cent of the whole and ethylene and carbon monoxide comprise 0.2 per cent each. No great error will be made, therefore, if these two latter gases are con-

sidered as being a part of the paraffin group, especially since ethylene and ethane do not differ greatly in either heating value or specific gravity. The inert gases may likewise be combined in one group, of which the resulting specific gravity may be considered equal to 1.0. Consequently, for approximate results, the average natural gas may be regarded as made up of three distinct gases, methane, ethane, and "inerts," of which the heating values and specific gravities may be considered as in Table 4.

29 Representing the relative volumetric proportions of these gases, expressed decimally, as m, e, and i, respectively, the following relations will obtain:

$$m+e+i=1.0 \qquad [1]$$

$$H=897m+1594e \qquad [2]$$

$$G=0.5529m+1.0368e+1.0i \qquad [3]$$

in which H = the lower heating value in b.t.u. per cu. ft. of natural gas at gas standard, and G = the specific gravity of the gas. Eliminating m and e from equations [1], [2], and [3], the heating value of the gas may be expressed in terms of i and G as follows:

$$H=1440G-1541i+100.6 \qquad [4]$$

30 The sum total of the percentages of the inerts given in Par. 21 is $0.061=i$. Substituting this in equation [4],

$$H=1440G+6.6 \qquad [5]$$

Applying equation [5] to the average gas of Table 2, of which the

TABLE 4 HEATING VALUE AND SPECIFIC GRAVITY OF METHANE, ETHANE AND INERTS

Kind of Gas	B.T.U. per Cu. Ft.	Specific Gravity
Methane	897	0.5529
Ethane	1594	1.0368
Inerts	....	1.0000

specific gravity is 0.6135, it would indicate the gas to have a fuel value of $H=890$ b.t.u. per cu. ft., as compared with a value of 887.3 as computed from analysis.

31 The values of H and G given in Table 1, when plotted against each other, yield the result shown in Fig. 1. In this figure, only those gases considered as representative, and not marked with an asterisk, have been plotted. The resulting points are very widely scattered, but the general tendency is toward an increasing value of H with increasing G, as would naturally be expected, and it must be remembered that many of the analyses plotted cannot be vouched

for as to accuracy, in fact it is reasonably certain that they are inaccurate. The diagonal line drawn in the figure is the graph of equation [5], and is not far from an average line through the points shown. It is fair to conclude, therefore, that for purely approximate work, a reasonable notion of the heating value of natural gas may be obtained from the known specific gravity by using equation [5]. When the locality is known from which the gas is derived, the approximate proportion of the inert gases may be learned by selecting, from Table 1, a gas from the same field, and the heating value com-

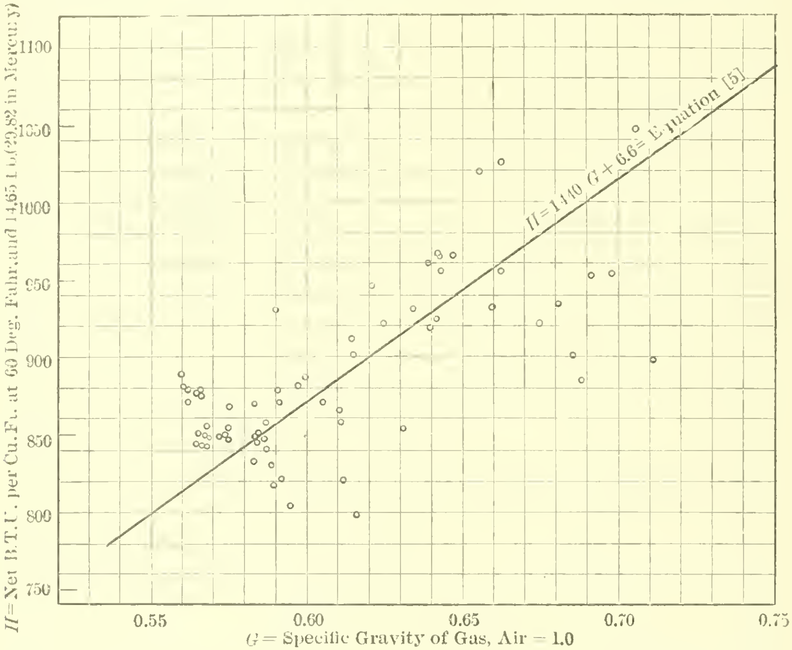


FIG. 1 CURVE SHOWING RELATIONS OF HEAT CONTENT AND SPECIFIC GRAVITY OF GAS, FROM TABLE 1

puted by means of equation [4]. The values calculated in this way are shown in column 15 of Table 1, and may be compared with those computed directly from the analyses.

32 As stated, no great degree of accuracy is claimed for this method of computation, but the author has frequently found it of great convenience where other and better methods were not available. The comparative values shown in the table as computed from the analyses and by equation [4], indicate that a fair degree of approximation can be attained by it.

33 Reference has been made to "dry" gas. This term is used to designate the ordinary natural gas coming from a well producing gas exclusively, as distinguished from that coming from an oil well, which is called "wet." These terms have no reference to water vapor in the gas, but imply the absence or presence of vapors of hydrocarbons higher in their respective series than those discussed above.

TRANSMISSION OF NATURAL GAS

34 *Pipe-Line Flow Formula.* In the design of pipe lines for the transmission of natural gas from the field to the points of consumption it is necessary to make use of a formula expressing the relations to each other of the quantity and initial and final pressures of the gas, and the diameter and length of line. Many such formulae have been proposed giving widely differing results. In nearly all of them the flow is stated as varying as the square root of the fifth power of the pipe diameter, and either the coefficient of friction is considered constant, or a different coefficient is given for each diameter of pipe. This serves well enough where the diameter is known and any one of the other quantities expressed by the formula is desired, but is somewhat awkward when it is desired to ascertain the diameter of line necessary to meet the other given conditions.

35 The author has derived a new formula, which he believes expresses the relationship of the quantities involved even more closely than any heretofore offered. It is based on isothermal flow, and the variation in the value of the coefficient of friction is provided for without complicating the formula, yet permitting the required diameter of line to be ascertained readily.

36 The expression for the initial velocity of any gas flowing in a pipe is given by Unwin [1] as

$$u_1 = \sqrt{\frac{gCTm}{fl} \frac{(P_1^2 - P_2^2)}{P_1^2}} \quad \ldots\ldots\ldots\ldots\ldots\ldots [6]$$

where

u_1 = initial velocity, ft. per sec.

g = acceleration due to gravity

C = thermodynamic constant of the flowing gas $= \dfrac{PV}{T}$

T = absolute temperature of gas

m = hydraulic mean radius of the pipe $= \dfrac{D}{4}$

[1] Compressed Air, p. 67, Van Nostrand's Science Series.

P_1 = absolute initial pressure of the gas, lb. per sq. in.
P_2 = absolute final pressure of the gas, lb. per sq. in.
f = coefficient of friction
l = length of line, ft.

Let

C_a = thermodynamic constant for air
G = specific gravity of flowing gas, air = 1.0
D = diameter of pipe, ft.
d = diameter of pipe, in.

Then

$$C = \frac{C_a}{G}$$

and

$$m = \frac{D}{4} = \frac{d}{48}$$

Hence

$$u_1 = \left[\frac{gC_a T(P_1^2 - P_2^2)d}{48\, GflP_1^2}\right]^{\frac{1}{2}} \qquad [7]$$

If

q = quantity of gas flowing per second, based on absolute pressure and temperature of P_o and T_o

A = area of cross-section of pipe in sq. ft. $= \frac{\pi d^2}{4 \times 144}$

Then

$$q = u_1 A \frac{P_1 T_o}{P_o T} = u_1 \frac{\pi d^2}{4 \times 144} \frac{T_o}{P_o} \frac{P_1}{T} = \frac{\pi}{576} \frac{T_o}{P_o} \left[\frac{gC_a(P_1^2 - P_2^2)d^5}{48\, GTfl}\right]^{\frac{1}{2}} \qquad [8]$$

If

Q = flow, cu. ft. per hr., based on P_o and T_o
L = length of line, miles.

Then

$$l = 5280L$$

and

$$Q = 3600q$$

$$Q = \frac{3600\pi}{576\sqrt{48 \times 5280}} \frac{T_o}{P_o} \sqrt{gC_a} \left[\frac{(P_1^2 - P_2^2)d^5}{GTfL}\right]^{\frac{1}{2}} \qquad [9]$$

Taking $g = 32.17$ and $C_a = 53.33$,

$$Q = 1.6156 \frac{T_o}{P_o} \left[\frac{(P_1^2 - P_2^2)d^5}{GTfL}\right]^{\frac{1}{2}} \qquad [10]$$

37 Experiments on the flow of air in pipes of different diameters indicate that the coefficient of friction f is a variable, decreasing with increasing diameters of line. A great many such experiments have been collected and published in Compressed Air, by Elmo G. Harris, from which, by the use of equation [10], the coefficients of friction have been computed and plotted in Fig. 2.

38 In the reports of these tests no statements were made as to the method of measuring the quantity of gas flowing, and it is quite probable that many of the results are inaccurate in this respect. Notwithstanding this, however, the nature of the variation of f with

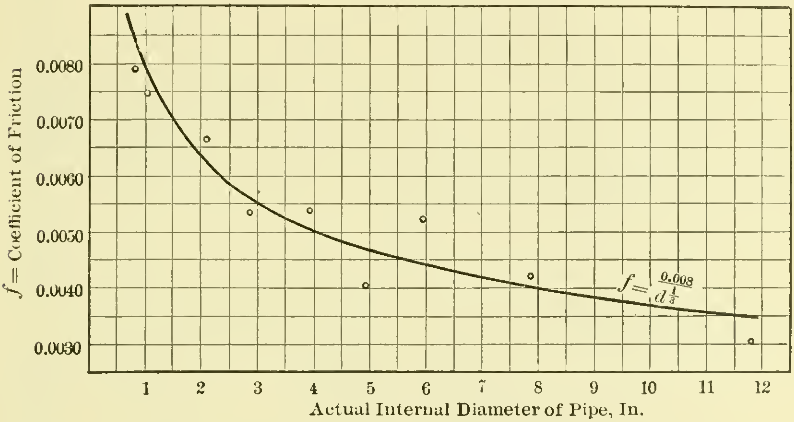


FIG. 2 CURVE SHOWING COEFFICIENT OF FRICTION OF FLOW OF AIR IN PIPES

the diameter is evident, and the curve represented by the equation

$$f = \frac{0.008}{\sqrt[3]{d}}$$

gives a fair average of the loci of the points plotted. Inserting this value of f in equation [10], the expression becomes

$$Q = 18.062 \frac{T_0}{P_0} \left[\frac{(P_1^2 - P_2^2) d^{5\frac{1}{3}}}{GTL} \right]^{\frac{1}{2}} \qquad [11]$$

Equation [11] is the general formula for the flow of gas in long pipe lines.

39 In 1901, Forrest M. Towl conducted an extended test on an 8-in. line, 70 miles long, supplying gas to Buffalo, the results of which were published in a bulletin issued by Columbia University in 1911. Previous to the test the line had been repaired and tested for leaks, and was known to be practically gas tight. The flow was measured

by standardized pitot tubes, which gave results accurate within less than 1 per cent. The specific gravity G of the flowing gas was 0.64, its temperature, 32 deg. fahr., or $T=492$ deg. absolute. The temperature basis on which the gas was measured was 50 deg. fahr., or $T_0=510$ deg. absolute, and the pressure basis was 4 oz. above 14.4 lb., or $P_0=14.65$ lb. per sq. in. absolute. In a length of pipe 70.32 miles long, P_1 and P_2 were 210 and 41 lb. per sq. in. absolute, respectively. The actual diameter of the pipe was 7.981 in., and the rate of flow by pitot tube was found to be 221,000 cu. ft. per hr.

40 Inserting these quantities in formula [6] and solving for flow, it becomes

$$Q=221{,}400 \text{ cu. ft. per hr.}$$

or less than 0.2 of 1 per cent greater than the actual flow as measured.

41 Assuming gas standard conditions of measurement basis, namely, 60 deg. fahr. and 14.65 lb. absolute pressure, and that the average flowing temperature of the gas throughout the year will be 40 deg. fahr., the formula becomes,

$$Q=28.66\left[\frac{(P_1^2-P_2^2)d^{5\frac{1}{3}}}{LG}\right]^{\frac{1}{2}}\ldots\ldots\ldots\ldots\ldots\ldots[12]$$

and, if an average specific gravity of 0.60 be assumed

$$Q=37\left[\frac{(P_1^2-P_2^2)d^{5\frac{1}{3}}}{L}\right]^{\frac{1}{2}}\ldots\ldots\ldots\ldots\ldots\ldots[13]$$

42 Formula [13] is of practical use in designing lines for the transmission of natural gas. It is used as given, or in a transposed form, for all problems relating to single lines of uniform diameter.

43 If a line is composed of several lengths, L_1, L_2, $\ldots L_n$, of diameters d_1, d_2, $\ldots d_n$, each of these lengths must be transformed into an equivalent length of one chosen diameter, by means of the formula

$$L_n^1=L_n\left[\frac{d_n^1}{d_n}\right]^{5\frac{1}{3}}\ldots\ldots\ldots\ldots\ldots\ldots[14]$$

These equivalent lengths added together will give $L=L_1'+L_2'+\ldots+L_n'$, which is the value for L in formula [13].

44 Values of equivalent lengths for different diameters can be most conveniently ascertained by the use of curves in Fig. 3, which consist of plots of the values of $d^{5\frac{1}{3}}$ for varying values of d. Values taken from these curves are convenient to use directly in the pipe-

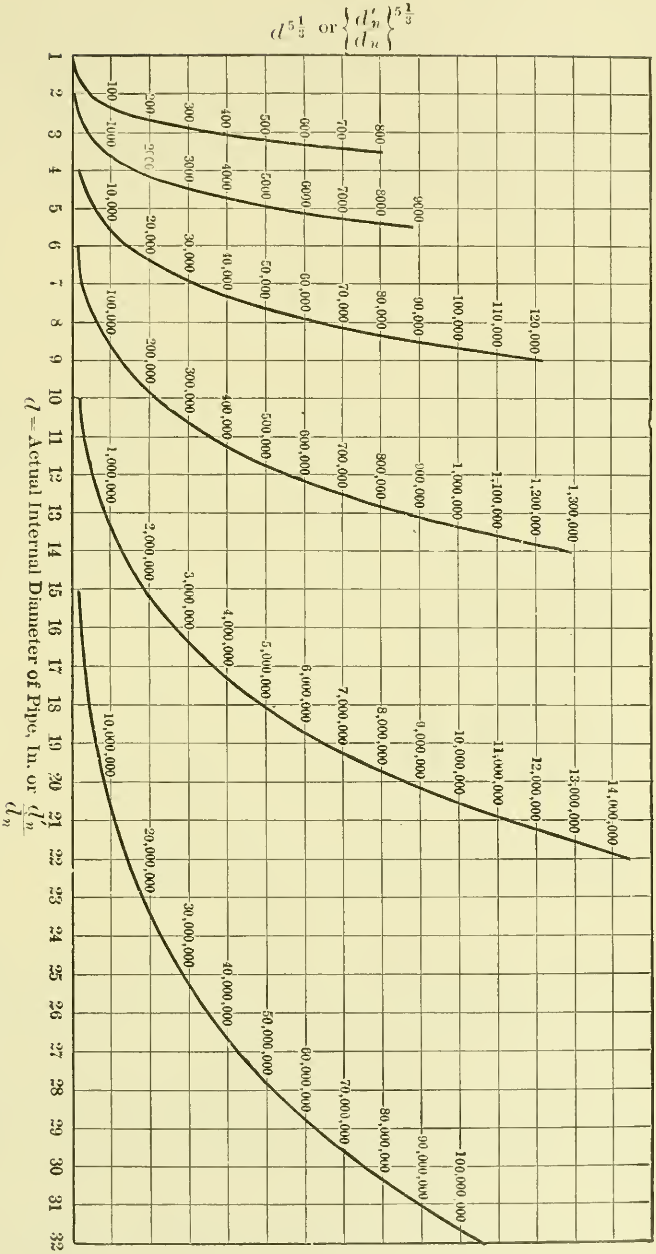


FIG. 3 CURVES SHOWING VALUES OF EQUIVALENT LENGTHS FOR DIFFERENT DIAMETERS OF PIPES

line formula, equation [13], whereas they are most simply used in equation [14] as values of the $5\frac{1}{3}$ power of the diameter ratios.

45 In the next case to be discussed, that of looped systems of lines (two or more pipes paralleling each other), it often happens that the several pipes of a loop have different lengths. It is then necessary, first, to transform all of them into their respective equivalents having a common length. This is done by means of a transposed form of equation [14], namely

$$d'_n = d_n \left[\frac{L'_n}{L_n}\right]^{\frac{3}{16}} \qquad [15]$$

It will be seen, of course, that these values can likewise be derived by the use of Fig. 3.

46 Having reduced the pipes to their equivalents of a common length L, let the equivalent diameters be d_1, d_2, $\ldots d_n$. The initial and final pressures P_1 and P_2 will be common to all, and therefore the flow per hour through the system will be

$$Q = 37\sqrt{\frac{P_1^2 - P_2^2}{L}}\left[\sqrt{d_1^{5\frac{1}{3}}} + \sqrt{d_2^{5\frac{1}{3}}} + \ldots + \sqrt{d_n^{5\frac{1}{3}}}\right] \qquad [16]$$

$$= 37\sqrt{\frac{(P_1^2 - P_2^2)}{L}}\ \Sigma\sqrt{d^{5\frac{1}{3}}} \qquad [17]$$

$$= 37\sqrt{\frac{(P_1^2 - P_2^2)d_o^{5\frac{1}{3}}}{L}} \qquad [18]$$

where

$$\sqrt{d_o^{5\frac{1}{3}}} = d_o^{\frac{8}{3}} = \Sigma\sqrt{d^{5\frac{1}{3}}} = \Sigma d^{\frac{8}{3}} \qquad [19]$$

or

$$d_o = \left[\Sigma d^{\frac{8}{3}}\right]^{\frac{3}{8}} \qquad [20]$$

47 If the whole line consists of other sections of similarly composed looped lines, the equivalent single diameter of each section can be determined by equation [20] and the section then reduced to an equivalent length of some chosen uniform diameter by equation [14]. These equivalent lengths added together will give a line of uniform diameter of single pipe equivalent to the actual looped system.

48 For facilitating the computation of such a line, Fig. 4 is given, which is a plot of values of $\sqrt{d^{5\frac{1}{3}}}$ for values of d. From these curves

the values of $\sqrt{d^{5\frac{1}{3}}}$ for the several loop diameters are read off and added together, the resulting equivalent diameter d_o being then ascertained from the curve.

49 *Pipe-Line Storage Capacity.* The storage capacity of a pipe line is the excess gas, over and above the average rate of supply, that

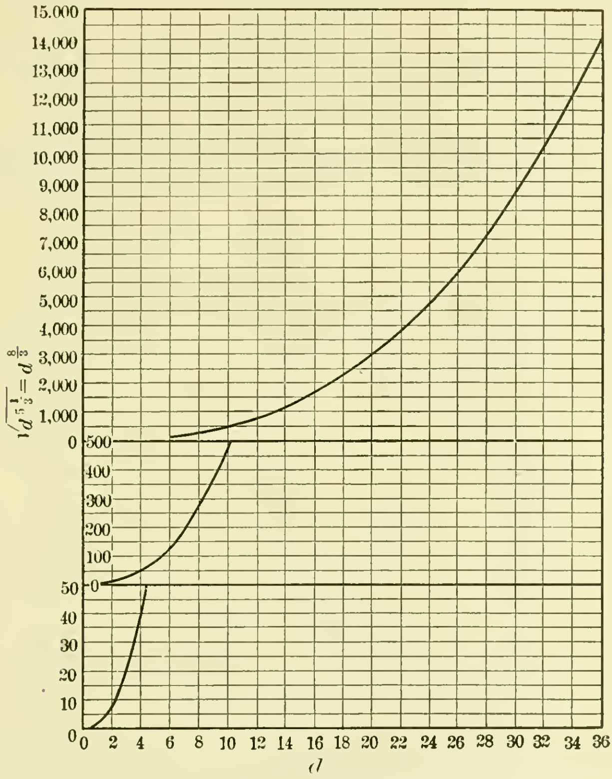


FIG. 4 CURVES GIVING DIAMETER OF PIPE RAISED TO $^8/_3$D POWER FOR USE IN COMPUTING PIPE LINES CONSISTING OF SECTIONS OF LOOPED LINES OF OTHER DIAMETERS

can be packed in the line during the period when the demand is less than the supply. The supply rate is the rate of average daily delivery and since the volume of gas contained in the line is a function of the pressure, it is necessary in order to determine the storage capacity, to develop an expression for the total line contents, which will take into account the variable pressure conditions at all points along the line. Having such an expression, the total contents under the

"packed" and "unpacked" conditions may be computed, and the storage ascertained by taking their difference.

50 The unpacked condition of a pipe line obtains when the gas is flowing at the average daily rate, for when the consumption is below this point all excess gas is being stored, and this point, therefore, is the lower limit, or base of the peaks in the daily delivery curve for the day.

51 The upper limit, or packed line condition, is not as readily determined, but if it is considered to be such that the intake pressure is at its maximum point, as fixed by considerations of safety, station pump pressure limits, etc., and the flow is a mean between the minimum and average rates for the day, the result will be very

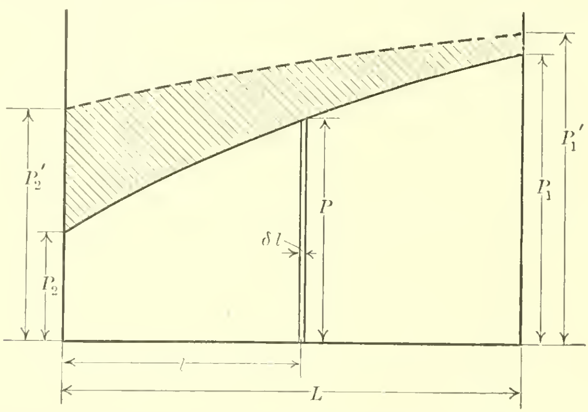


FIG. 5 VARIATION OF INTAKE PRESSURE P_1 FOR VARYING VALUES OF L, LENGTHS OF PIPE, WITH DISCHARGE PRESSURE P_2 CONSTANT

nearly actual conditions, and whatever error may thereby be involved will be on the side of safety in estimating the storage capacity.

52 Fig. 5 shows the variation of intake pressure P_1 for varying values of L with the discharge pressure P_2 constant. Two curves are plotted: The solid line represents the conditions with an assumed average rate of flow and the discharge pressure P_2 fixed by the minimum value allowable by the requirements of the distributing system. The dotted line represents the pressure conditions in the same line with the intake pressure P_1 at the maximum allowable value, and the flow at an assumed mean of the minimum and average rates for the day. This latter curve represents the packed line, and the shaded area the quantity of gas stored in the line available for peak loads.

53 Let P=absolute pressure at any point; then for any given line and flow condition, from equation [13]

$$P^2-P_2^2=l\frac{Q^2}{\overline{37}^2 d^{5\frac{1}{3}}}=Kl \ldots\ldots [21]$$

wherein

$$K=\frac{Q^2}{\overline{37}^2 d^{5\frac{1}{3}}} \ldots\ldots [22]$$

Hence

$$P=\sqrt{Kl+P_2^2} \ldots\ldots [23]$$

The gas contained in a length δl based on any pressure P_o will be in cu. ft.,

$$\delta V=5280\ A\cdot\delta l\cdot\frac{P}{P_o}$$

where A is the cross-sectional area of the pipe in sq. ft. The total quantity of gas in the line under the given conditions will then be

$$V=\int\delta V=5280\frac{A}{P_o}\int_0^L\sqrt{Kl+P_2^2}\,\delta l=\frac{3520}{K}\frac{A}{P_o}\left[(KL+P_2^2)^{\frac{3}{2}}-P_2^3\right].[24]$$

But

$$KL=P_1^2-P_2^2 \text{ and } K=\frac{P_1^2-P_2^2}{L}$$

Hence

$$V=\frac{3520\ AL}{P_o(P_1^2-P_2^2)}\left[P_1^3-P_2^3\right]$$

$$=3520\frac{AL}{P_o}\left[P_1+P_2-\frac{P_1P_2}{P_1+P_2}\right] \ldots\ldots [25]$$

$$=19.20\frac{d^2L}{P_o}\left[P_1+P_2-\frac{P_1P_2}{P_1+P_2}\right] \ldots\ldots [26]$$

54 In these formulae d is the actual internal diameter of the pipe in inches, and L the length of line in miles, the pressures all being lb. per sq. in. absolute.

55 In the case of a complex system it is necessary, first, to ascertain the common pressures at all junction points where the lines are tied together, and then to compute separately the capacity of each section. To do this it is necessary to use the actual diameter, or area, and length of each of the pipes in the loop. The gas content of a looped section thus becomes

$$V=\frac{3520}{P_0}\left[P_1+P_2-\frac{P_1P_2}{P_1+P_2}\right]\Sigma AL \ldots\ldots\ldots [27]$$

or

$$V=\frac{19.20}{P_0}\left[P_1+P_2-\frac{P_1P_2}{P_1+P_2}\right]\Sigma d^2L \ldots\ldots\ldots [28]$$

56 The gas content of the entire system will thus be the sum of the contents obtained for the several sections of line. If the quantity thus obtained for average flow conditions is deducted from that similarly computed for minimum flow with maximum intake pressure P_1, the result will be the total available storage capacity of the line.

57 If the letters used in equations [27] and [28] be taken to represent the pressure conditions of the packed lines and P_1' and P_2'

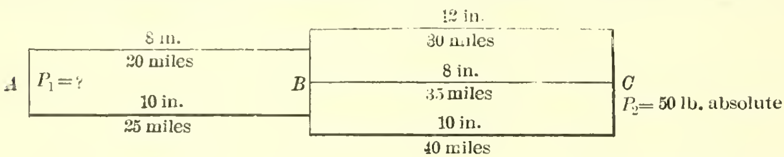


FIG. 5-a DIAGRAM ILLUSTRATING APPLICATION OF PIPE-LINE FORMULAE

those of the unpacked line, the available storage capacity of the system will be

$$S=\frac{3520}{P_0}\left(P_1-P_1'+P_2-P_2'-\frac{P_1P_2}{P_1+P_2}+\frac{P_1'P_2'}{P_1'+P_2'}\right)\Sigma AL \ldots [29]$$

or

$$S=\frac{19.20}{P_0}\left(P_1-P_1'+P_2-P_2'-\frac{P_1P_2}{P_1+P_2}+\frac{P_1'P_2'}{P_1'+P_2'}\right)\Sigma d^2L \ldots [30]$$

58 The following problem will illustrate the application of all of the above pipe-line formulae. Assume a complex line made up as shown in Fig. 5-a, and let it be required to find the equivalent line of single pipe and the intake, or initial pressure P_1 necessary to force 1,000,000 cu. ft. per hr. through the system, with a terminal pressure $P_2=50$ lb. absolute. Taking first the section from A to B, we have 20 miles of 8-in. (net) pipe and 25 miles of 10-in. By equation [15] the diameter of a pipe 25 miles long that will be equivalent to the 20 miles of 8-in. pipe is, in inches

$$d_n'=8\left(\frac{25}{20}\right)^{\frac{3}{16}}=8.342$$

Section AB is then equivalent to two parallel or looped lines each 25 miles long and having respective diameters of 8.342 in. and 10 in.

$$\begin{array}{ll} \text{For } d = 8.342 \text{ in.} & d^{\frac{8}{3}} = 286.2 \text{ in.} \\ \text{for } d = 10.0 & d^{\frac{8}{3}} = 464.2 \\ \hline & \Sigma d^{\frac{8}{3}} = 750.4 \text{ in.} \end{array}$$

and by equation [20]

$$d_o = (\Sigma d^{\frac{8}{3}})^{\frac{3}{8}} = (750.4)^{\frac{3}{8}} = 11.97$$

or, section AB is equivalent to one pipe 11.97 in. in diameter and 25 miles long.

59 By equation [15] in section BC, the 8-in. pipe, 35 miles long is equivalent to a 7.772-in. pipe 30 miles long, since

$$d'_n = 8 \left[\frac{30}{35}\right]^{\frac{3}{16}} = 7.772$$

60 In the same manner, the 10-in. line 40 miles long, is equivalent to a 9.475-in. line 30 miles long. Then, by equation [20]

$$\begin{array}{ll} \text{for } d = 12.0 & d^{\frac{8}{3}} = 754.8 \\ d = 7.772 & d^{\frac{8}{3}} = 237.0 \\ d = 9.475 & d^{\frac{8}{3}} = 402.0 \\ \hline & \Sigma d^{\frac{8}{3}} = 1393.8 \end{array}$$

$$d_0 = (\Sigma d^{\frac{8}{3}})^{\frac{3}{8}} = (1393.8)^{\frac{3}{8}} = 15.10 \text{ in.}$$

Hence section BC is equivalent to one pipe 15.10 in. in diameter, 30 miles long. By equation [14]

$$L'_n = 30 \left(\frac{11.97}{15.10}\right)^{5\frac{1}{3}} = 8.68 \text{ miles}$$

61 Thus, section BC is equivalent to a single line 11.97 in. in diameter and 8.68 miles long and the whole system is equivalent to a single line 11.97 in. in diameter and 33.68 miles long.

62 For ascertaining the required initial pressure for a flow of 1,000,000 cu. ft. per hr. the known line constants are therefore, $P_2 = 50$, $d = 11.97$, $L = 33.68$, $Q = 1{,}000{,}000$. By equation [13]

$$1{,}000{,}000 = 37 \sqrt{\frac{P_1^2 - 50^2}{33.68} \; 11.97^{5\frac{1}{3}}}$$

$$P_1 = 215.1 \text{ lb. absolute}$$

63 The relative quantities of gas passed by the several pipes of the loops are to each other as the $\frac{8}{3}$d power of their equivalent diam-

eters for equal lengths. The pressure at junction B can be ascertained by means of equation [13], using for L and d the equivalent values derived above for section AB. This pressure is required to be known in order to determine the storage capacity of the line. After having ascertained the above quantities, the pressure drops being known, the computation can be checked by computing the flow through the several lines as they actually exist.

64 Instead of computing the equivalent lengths and diameters by equations [14], [15], and [20], they may be ascertained from the curves of Figs. 3 and 4.

65 To compute the storage capacity of the system, first consider section AB. Assume the maximum allowable pressure at A to be $P_1 = 225$ lb. absolute, and the flow $Q = 800{,}000$ cu. ft. per hr. This section was shown to be equivalent to a single line 11.97 in. in diameter and 25 miles long. Substituting these known values in equation [13], the pressure at B is found to be $P_2 = 172.7$ lb.

66 When the line is unpacked; that is, under average flow conditions of 1,000,000 cu. ft. per hr. P_1' was shown to be 215.1 lb. and by formula [13], P_2' is found to be 117.4 lb.

67 Substituting these values in equation [30], together with the actual dimensions of the pipe in the section of line under consideration, the available storage capacity of this section AB in cu. ft. is

$$S = \frac{19.20}{14.65}\left(225 - 215.1 + 172.7 - 117.4 - \frac{225 \times 172.7}{225 + 172.7}\right.$$

$$\left. + \frac{215.1 \times 117.4}{215.1 + 117.4}\right)\left(8^2 \times 20 + \overline{10}^2 \times 25\right) = 215{,}000$$

68 In like manner the storage capacity of BC is computed, the sum of the two results being the total storage capacity of the whole system available for peak demands.

69 *Power Required to Compress Natural Gas.* Before discussing the general problem of the design of a transmission system, it is necessary to give a rational formula for the power required to pump natural gas. It has generally been assumed that the compression is approximately adiabatic, and the theoretical adiabatic formula has been used for determining the power requirements. Many tests on compressors of widely differing types have convinced the author that this formula sometimes leads to serious errors, and, accordingly, an empirical formula is presented, which is believed to represent the actual operating conditions much more closely than the adiabatic

formula. First, however, both the isothermal and adiabatic formulae will be presented for purposes of comparison.

70 If gas could be compressed isothermally, the theoretical work required, as derived from the laws of perfect gases and with no clearance in the compressor, would be

$$W = P_1 V_1 \log_e \frac{P}{P_1} \quad \text{[31]}$$

where

W = ft-lb. of work per lb. of gas compressed
P_1 = absolute suction pressure, lb. per sq. ft.
P_2 = absolute discharge pressure, lb. per sq. ft.
V_1 = volume of 1 lb. of gas at pressure P_1, cu. ft.

Let

P_o = absolute pressure, lb. per sq. ft. on which the measurement of the gas is based
T_o = absolute temperature basis of measurement, deg. fahr.
V_o = volume of 1 lb. of gas at P_o and T_o
T_1 = absolute temperature at which the gas is compressed

Then

$$\frac{P_1 V_1}{T_1} = \frac{P_o V_o}{T_o}$$

and

$$P_1 V_1 = P_o V_o \frac{T_1}{T_o}$$

hence

$$W = P_o V_o \frac{T_1}{T_o} \log_e \frac{P_2}{P_1} \text{ ft-lb.} \quad \text{[32]}$$

71 At P_o and T_o 1,000,000 cu. ft. of gas will weigh $\dfrac{1{,}000{,}000}{V_o}$ lb. and if 1,000,000 cu. ft. are compressed in one day of 24 hours (1440 minutes), there will be $\dfrac{1{,}000{,}000}{1440\ V_o}$ lb. compressed per minute. Hence it will require

$$\frac{1{,}000{,}000}{1440\ V_o} \frac{P_o V_o T_1}{T_o} \log_e \frac{P_2}{P_1} \text{ ft-lb. per min.}$$

or

$$\frac{1{,}000{,}000}{1440 \times 33000} \frac{T_1}{T_o} P_o \log_e \frac{P_2}{P_1} \text{ h.p.}$$

72 If p_o = the base pressure in lb. per sq. in. absolute, and p_2 and p_1 are absolute pressures per sq. in. corresponding to P_2 and P_1

$$P_o = 144\ p_o$$

and

$$\text{h.p.}_i = \frac{1{,}000{,}000 \times 2.3026 \times 144}{1440 \times 33000}\, p_o \frac{T_1}{T_o} \log_{10} \frac{p_2}{p_1} = 6.978\ p_o \frac{T_1}{T_o} \log \frac{p_2}{p_1} \quad [33]$$

H.p.$_i$ is the theoretical isothermal horsepower per 1,000,000 cu. ft. of gas per day.

73 This formula gives the least possible power required to compress gas at the rate of 1,000,000 cu. ft. per day, and is therefore used as a measure of the efficiency of compression. In other words, "compression efficiency" is the figure obtained by dividing the h.p. as determined from equation [33] by that actually required on the compressor piston.

74 If the compression were performed strictly according to the adiabatic law where n is the ratio of specific heats of the gas at constant pressure and constant volume, the work, neglecting clearance, required for 1 lb. of gas would be, theoretically,

$$W = \frac{n}{n-1} P_1 V_1 \left[\left(\frac{P_2}{P_1}\right)^{\frac{n-1}{n}} - 1\right] \quad [34]$$

But since

$$P_1 V_1 = P_o V_o \frac{T_1}{T_o}$$

$$W = \frac{n}{n-1} P_o V_o \frac{T_1}{T_o}\left[\left(\frac{P_2}{P_1}\right)^{\frac{n-1}{n}} - 1\right] \quad [35]$$

75 In order to compress 1,000,000 cu. ft. per day, it would require, as before,

$$\text{h.p.}_a = \frac{1{,}000{,}000}{1440 \times 33000 \times V_o} \frac{n}{n-1}\, 144\ p_o V_o \frac{T_1}{T_o}\left[\left(\frac{p_2}{p_1}\right)^{\frac{n-1}{n}} - 1\right]$$

$$= 3.03\ p_o \frac{T_1}{T_o} \frac{n}{n-1}\left[\left(\frac{p_2}{p_1}\right)^{\frac{n-1}{n}} - 1\right] \text{h.p.} \quad [36]$$

76 As already stated, the bases generally adopted throughout the gas country are $p_o = 14.65$ lb. per sq. in. and $T_o = 60 + 460 = 520$ deg.; also, for average natural gas, $n = 1.266$. Substituting these values, and assuming $T_1 = T_o = 520$ deg., formula [33] for isothermal compression, becomes

$$\text{h.p.}_{\text{i}} = 102.23 \log \frac{p_2}{p_1} \quad \text{[37]}$$

and formula [36] for adiabatic compression, becomes

$$\text{h.p.}_{\text{a}} = 211.27 \left[\left(\frac{p_2}{p_1} \right)^{0.21} - 1 \right] \quad \text{[38]}$$

77 Equations [37] and [38] give the theoretical h.p. per 1,000,000 cu. ft. per day, for isothermal and adiabatic compression respectively, on the assumption that the compressors have no clearance and that there are no losses of any kind. Obviously these conditions are impossible of realization in practice and experience shows that while one would expect the true formula to be somewhere between those for adiabatic and isothermal conditions, due to jacket cooling, in reality this is not the case, on account of the effects of mechanical clearance and slippage losses, to be explained later.

78 For isothermal compression the mean effective pressure in lb. per sq. in., as derived from equation [31], is

$$\text{m.e.p.}_{\text{i}} = 2.3026\ p_1 \log \frac{p_2}{p_1} \quad \text{[39]}$$

79 For adiabatic compression, derived from equation [34], it is

$$\text{m.e.p.}_{\text{a}} = \frac{n}{n-1}\ p_1 \left[\left(\frac{p_2}{p_1} \right)^{\frac{n-1}{n}} - 1 \right] \quad \text{[40]}$$

which, for natural gas, when $n = 1.266$, is

$$\text{m.e.p.}_{\text{a}} = 4.76\ p_1 \left[\left(\frac{p_2}{p_1} \right)^{0.21} - 1 \right] \quad \text{[41]}$$

80 If p_2 in equations [39] and [41] be regarded as constant and equal to 100 per cent, and p_1 be allowed to vary from 0 to 100, and the results plotted with values of m.e.p. as ordinates and values of p_1, as abscissae, the resulting curves will be shown as I and A respectively, of Fig. 6. The maximum, or peak load point for the isothermal curve I occurs at

$$p_1 = 0.3679\ p_2, \text{ or } \frac{p_2}{p_1} = e = 2.718$$

For the adiabatic curve A, it occurs at

$$p_1 = 0.3254\ p_2, \text{ or } \frac{p_2}{p_1} = n^{\frac{n}{n-1}} = 3.073$$

81 By referring to equations [37] and [38], it is seen that the power required to pump a given volume of gas is dependent solely upon the ratio of discharge to suction pressures, irrespective of the actual

value of either of them, whereas equations [39] and [41] show the mean effective pressure to depend upon the absolute value of the suction pressure, as well as upon the number of compressions. They show further that, as the suction increases from zero to the value of the discharge pressure, the latter remaining fixed, the mean effective pressure increases, theoretically, from zero to a maximum value, and then decreases to a theoretical zero when the suction is equal to the discharge. As a matter of fact, however, the indicated mean effective pressure in the compressor cylinder will not fall to zero with suction and discharge pressures equal, due to the wire-drawing of the dense gas through the valves, resulting in a diminution during the admission stroke, of the pressure in the cylinder below that in the suction line, and in a piling up, during the discharge stroke, of the pressure above that in the discharge line. Consequently, with suction and discharge pressures equal, the actual indicated power will always be greater than that of either the isothermal or the adiabatic.

82 With $p_1=0$, that is, when no gas is admitted to the compressor, the indicator card will show the compression and re-expansion lines to be practically superimposed if the valves are tight, and consequently the condition of zero work with zero suction pressure is very nearly attained in practice.

83 It has been the custom of most engineers to consider that the actual mean effective pressure of compression follows the adiabatic law, and they have therefore used equations [39] and [41], with constants depending upon assumed values of inefficiency, or lost work, according to the judgment and experience of the engineer. Repeated tests have shown, however, that the work curve has characteristics more nearly approaching those of the isothermal than those of the adiabatic, and in every case of which the author has any record the actual curve begins at zero, for zero suction, and rises between the isothermal and adiabatic curves until a point is reached, at about 3.2 compressions, where it crosses the adiabatic and thereafter continues above it. The peak load is found at about $p_1=0.42\,p_2$ or $\frac{p_2}{p_1}=2.38$ compressions.

84 In Fig. 6 are plotted the results of two independent tests on compressors of large size. The circled dots represent the observations of a test reported by James S. Posgate, of the Kansas Natural Gas Company, in a paper[1] read before the Natural Gas Association

[1] Operation of Compression Stations, The Natural Gas Journal, August 1911, p 20

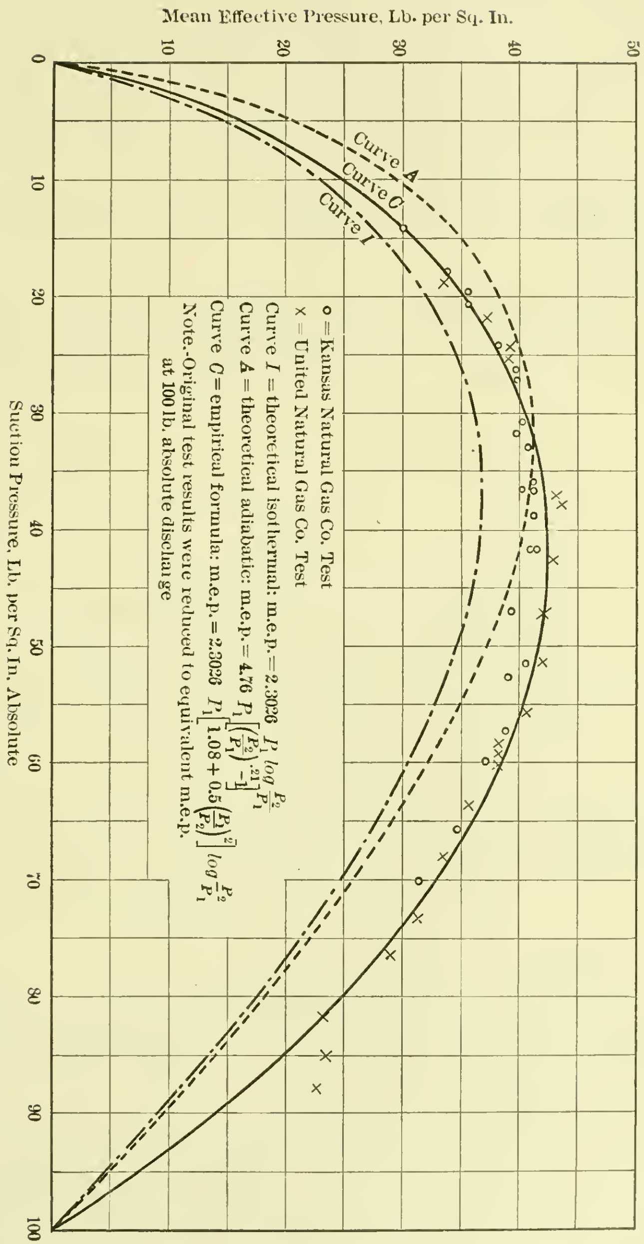


Fig. 6 Results of Two Independent Tests for Compressors of Large Size

of America at its sixth annual meeting, May 1911. The unit comprised two 17 in. by 48 in. compressor cylinders, operating at 260 lb. gage. The crossed points represent the observations of a test conducted by the author, in March 1911, on a $24\frac{3}{4}$ in. by 48 in. compressor running at 88 r.p.m. In the latter test the discharge pressure was held constant at about 103 lb. gage, and the suction pressure varied from 88 to 19 per cent of the discharge. The results of the observations in both tests were reduced to equivalent values corresponding to a constant discharge pressure of 100 lb. per sq. in. absolute.

85 A study of the plotted observations of these tests in comparison with the curves A and I in the same figure, reveals the fact that the actual curve attained in practice resembles the isothermal more

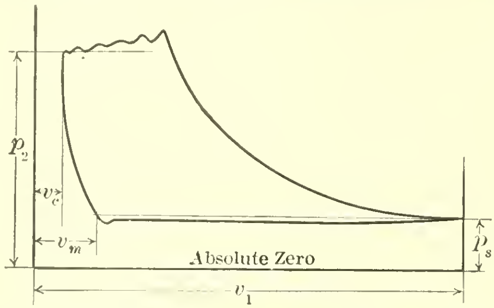


Fig. 7 Typical Compressor Diagram—see Par. 89

nearly than it does the adiabatic; and that it diverges from the isothermal at a comparatively uniform rate as the suction pressure increases, and can be fairly represented by the equation

$$\text{m.e.p.} = 2.3p_1\left[1.08+0.5\left(\frac{p_1}{p_2}\right)^2\right]\log\frac{p_2}{p_1} \ldots\ldots\ldots\ldots [42]$$

which is plotted as curve C in Fig. 6.

86 Curve C and its corresponding equation [42] may be taken as fairly representing the conditions met with in practice and has been found by the author to be safe to use in predetermining the indicated horsepower of a compressor.

87 The peculiar relationship existing between the actual and the isothermal curves is doubtless to be explained by the increased rate of cooling of the gas with increasing range of compressions, for the lower the suction pressure, and therefore the greater the number of compressions, the higher will be the temperature of compression and

the less the weight of gas pumped, with correspondingly less total quantity of heat generated. These results combined will therefore cause an increased rate of flow of heat into the cooling water, while at the same time less total quantity of heat will have to be extracted from the gas, with the result that the compression will more and more nearly approach isothermal conditions.

88 Inasmuch as the formula for the mean effective pressure represented by equation [42] is derived from actual operating conditions, it may be considered as taking into account all power losses. In the development of a working formula for the actual power required to pump a given quantity of gas, however, there are a number of sources of loss in volumetric efficiency which must be considered, the most important of which are as follows:

a Mechanical clearance

b Wire-drawing of the gas passing through suction valves and passages

c Heating of the inlet gas while entering the cylinder

d Valve and piston leakage

89 From a study of a great variety of indicator cards taken from many different types of compressors, the author has found that the re-expansion curve closely resembles the isothermal. In fact, many instances were found where its exponent was less than 1.0, doubtless due to discharge valve leakage. Assuming, therefore, that for practical purposes it may be considered as following the isothermal law,

$$p_2 v_c = p_s v_m$$

where p_2, p_s, v_c, and v_m are as represented in Fig. 7.
Hence

$$v_m = \frac{p_2}{p_s} v_c$$

Volumetric efficiency equals

$$E_i = \frac{v_1 - v_m}{v_1 - v_c} = \frac{v_1 - \frac{p_2}{p_s} v_c}{v_1 - v_c}$$

If the piston displacement $= 1.0$, then $v_1 - v_c = 1.0$ and $\frac{v_c}{v_1 - v_c} = v_c = m =$ clearance, expressed decimally. Hence

$$v_1 = 1 + m$$

and volumetric efficiency equals

$$E_i = 1 - m\left(\frac{p_2}{p_s} - 1\right) \qquad [43]$$

90 Equation [43] expresses the indicated volumetric efficiency of the compressor, i.e., the efficiency as measured on the indicator card.

91 The *indicated output* includes the effect of wire-drawing, or reduction of effective suction pressure of the gas due to passing through the suction valves and passages, as well as that of the indicated volumetric efficiency. In other words, the indicated output is determined by multiplying the piston displacement by the indicated volumetric efficiency and the absolute suction pressure *in the cylinder,* as measured from the cards, and dividing by the absolute pressure base on which the gas is measured. This wire-drawing effect reduces the compressor capacity and increases the power required to pump gas from a given line suction pressure in proportion to the extent of the pressure reduction. This is expressed as a percentage of the absolute line suction pressure. It must be included in the expression for indicated volumetric efficiency by making p_s in equation [43] equal to kp_1, where k is 1.0 minus the percentage drop in suction pressure due to wire-drawing, and p_1 is the line suction pressure, absolute. Hence, the indicated efficiency, expressed in terms of the line suction pressure, is

$$E_i = 1 - m\left(\frac{p_2}{kp_1} - 1\right) \qquad [44]$$

92 The third source of loss, heating of the inlet gas entering the cylinder, is an effect that is difficult to determine directly. In 1909 the author conducted a series of tests on six different compressing units, three high-stage and three low, in an effort to discover to what extent this heating occurred, and found that, as was to be expected, it increased with increasing compression ratios, and was affected in a marked degree by any leakage that occurred through discharge valves or past the pistons. Its effect on volumetric efficiency was to reduce it in direct proportion to the ratio of absolute temperature in the suction line to that of the cylinder full of gas at the beginning of compression, and amounted roughly to about 1 per cent for each 5 deg. fahr. difference.

93 The fourth factor, namely, the loss due to leakage, reduced both the volumetric and the work efficiencies. While leaky suction valves caused a flattening of the compression line of the card and thus a reduction in the mean effective pressure, the quantity of gas pumped was also reduced with the net result of an increase in the power required for a given actual quantity of gas discharged. On the other hand, a leak back through the discharge valves into the

cylinder reduced the quantity of gas drawn in through the suction, not only by displacement, but also by its heating effect. It also raised the pressure during the compression stroke, making the compression line steeper, and thereby caused an increase in the mean effective pressure. The ultimate result, therefore, was an increased power requirement to pump a given quantity of gas.

94 In accounting for the losses due to heating and to leakage, they are usually combined with all unaccounted for losses, and called "slippage," for which a certain fixed percentage is assumed and inserted in the expression for volumetric efficiency.

95 Let s, expressed as a decimal, be the slippage effect. Then the actual efficiency or ratio of gas actually pumped, to that computed from piston displacement, would be

$$E = 1 - m\left(\frac{p_2}{kp_1} - 1\right) - s \quad \ldots\ldots\ldots\ldots [45]$$

and the quantity of gas pumped in one day of 1440 minutes would be, in millions of cubic feet, based on T_o and p_o

$$Q_m = \frac{1440}{1{,}000{,}000}\,\frac{A}{144}\,LN\,\frac{T_o}{T_1}\,\frac{kp_1}{p_o}\left[1 - m\left(\frac{p_2}{kp_1} - 1\right) - s\right] \ldots\ldots [46]$$

The horsepower required on the compressor piston will be

$$\text{h.p.} = \frac{\text{m.e.p.} \times L \times A \times N}{33000}$$

The horsepower per 1,000,000 cu. ft. per day will thus be equal to

$$\text{h.p.}_m = \frac{\text{h.p.}}{Q_m} = \frac{100}{33}\,\frac{T_1}{T_o}\,\frac{\text{m.e.p.}}{\frac{kp_1}{p_o}\left[1 - m\left(\frac{p_2}{kp_1} - 1\right) - s\right]} \ldots\ldots\ldots [47]$$

Substituting the value of m.e.p. as given in equation [42]

$$\text{h.p.}_m = \frac{100}{33} \times 2.3026 \times p_o \times \frac{T_1}{T_o} \times \frac{1.08 \times 0.5\left(\frac{p_1}{p_2}\right)^2}{k\left[1 - m\left(\frac{p_2}{kp_1} - 1\right) - s\right]}\log\frac{p_2}{p_1} \ . [48]$$

or, if $\frac{p_2}{p_1} = r$

$$\text{h.p.}_m = 6.978\ p_o\,\frac{T_1}{T_o}\,\frac{1.08 + \frac{1}{2r^2}}{k\left[1 - m\left(\frac{r}{k} - 1\right) - s\right]}\log r \ldots\ldots [49]$$

96 For average conditions in practice, $m=0.02$, $k=0.98$, $s=0.04$, and $p_o=14.65$. Substituting these values in [49]

$$\text{h.p.}_m = 102.2 \frac{1.08+\frac{1}{2\,r^2}}{0.96-0.02\,r} \log r \quad \text{[50]}$$

97 The efficiency of compression is equation [37] divided by equation [50], or

$$E_c = \frac{0.96-0.02\,r}{1.08+\frac{1}{2\,r^2}} \quad \text{[51]}$$

98 In two-stage compression, for equal work in both stages, the power required is equal to twice that necessary to pump the gas through a single stage in which the number of compressions is equal to the square root of the total two-stage compression range. Therefore, if $\text{h.p.}_2=$ the horsepower per 1,000,000 for two-stage operation,

$$\text{h.p.}_2 = 2\times 6.978\, p_o \frac{1.08+\frac{1}{2r}}{k\left[1-m\left(\frac{\sqrt{r}}{k}-1\right)-s\right]} \log \sqrt{r}$$

$$= 6.978\, p_o \frac{1.08+\frac{1}{2\,r}}{k\left[1-m\left(\frac{\sqrt{r}}{k}-1\right)-s\right]} \log r \quad \text{[52]}$$

Substituting the same constants as were assumed for equation [50]

$$\text{h.p.}_2 = 102.2 \frac{1.08+\frac{1}{2\,r}}{0.96-0.02\sqrt{r}} \log r \quad \text{[53]}$$

99 The simplest method of using the horsepower formula is by means of a plot giving values of horsepower per 1,000,000 cu. ft. of gas per day corresponding to values of $\frac{p_2}{p_1}=r$. Equations [37], [38] and [50] are so plotted in Fig. 8, together with the efficiency of compression, equation [51].

100 It will be seen that whereas the actual mean effective pressure in the compression of natural gas is less than that of true adiabatic compression for ranges above 3.2 compressions, the actual horsepower required to pump a given quantity of gas is always

greater, no matter what the compression range may be. This is due to the effect of clearance and the other losses discussed above.

101 The curves in Fig. 8 give the indicated horsepower required on the compressor piston, and in order to determine that necessary in the power cylinders, the values taken from the curves must be increased according to the mechanical efficiency of the machine.

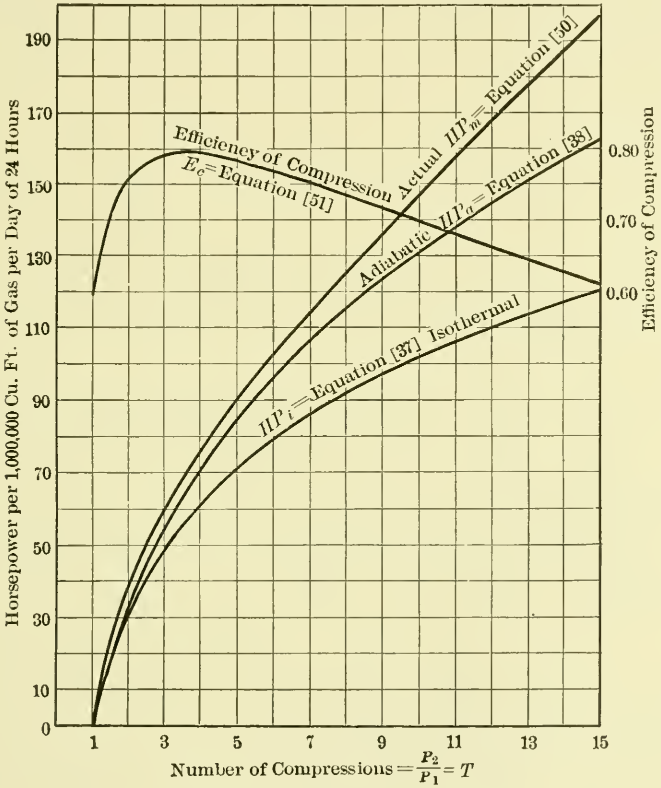


FIG. 8 PLOT OF EQUATIONS [37], [38], [50] AND [51]

This efficiency will range from 75 to 80 per cent in direct-connected gas-engine-driven compressors of large size.

102 Single-stage compression is advisable for ranges up to seven or eight compressions for the reason that the benefit that would be derived from two-stage operation is overbalanced by the excess first cost of the units, combined with the greater cost of operating, installing, and housing them. As the compression range increases above this point, however, two-stage operation becomes necessary

from an operating standpoint, and its advantage from an economical standpoint becomes more and more pronounced.

103 In compressing natural gas through two or more stages it is found to be impracticable to drive the compressors of all stages by the same power unit, on account of the variable pressure conditions which unbalance the loads of the different stages except at one particular ratio of compression. For this reason it is the usual practice to have the compressors of each stage driven by their own individual power units.

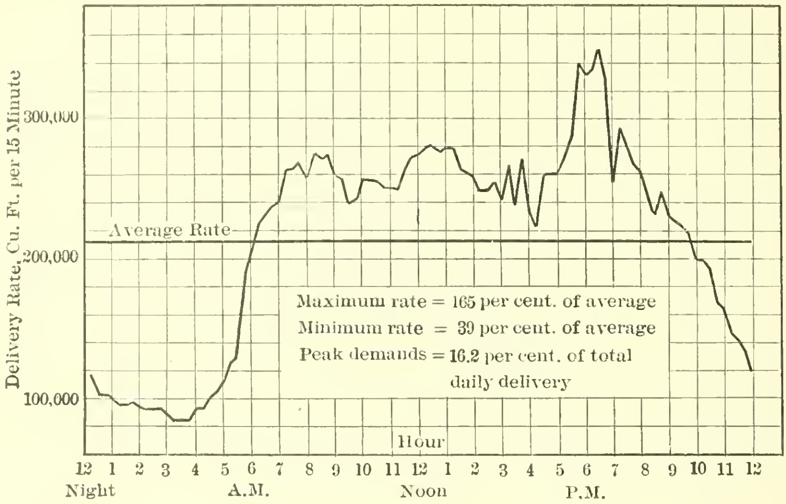


FIG. 9 LOAD CURVE SHOWING DELIVERY OF GAS DURING A COLD DAY IN WINTER

104 It is seldom, if ever, advisable to pump through more than two stages in natural gas transmission, for the reason that the pressure is limited by the strength of the pipe lines to a value that would not warrant the added complication and cost of multi-stage units higher than two.

105 *Pipe-Line Design.* In order to design a transmission system it is necessary to consider the character of service to be rendered and the various load factors to be expected. For domestic service in large cities the maximum daily delivery during the year will be about twice the daily average for the year, while the minimum will range from 25 to 30 per cent of the average. Thus, if 7,300,000,000 cu. ft. of gas are to be delivered in a year, or an average of 20,000,000 per day, provision will have to be made to transport 40,000,000 dur-

ing the coldest day of winter. The load curve for a typical cold day must then be considered and the pipe lines and stations designed not only to deliver the total quantity for the day at the average hourly rate, but also to provide sufficient storage capacity to carry the load safely over the peaks. A typical load curve for a cold day is shown in Fig. 9, and it will be seen that there are three main peaks, occurring about at meal times. As a rule, the demand for gas during the peaks will amount to about 16 per cent of the total daily delivery. The line storage capacity will therefore have to be equal, at least, to this amount. It is thus necessary to provide a line of sufficient capacity to transport the daily average with ease, and to have the requisite storage capacity. At the same time the pumping stations will be required not only to pump the average quantity of gas demanded, but will be required to pump it to a pressure sufficiently high to pack the line, and thus give it the proper storage. This packing must, of course, be done during periods of depression in the daily load curve, when the demand is less than the supply from the stations.

106 There are many variables involved in the proper design of a pipe line for greatest economy, such as: the pressure to be adopted; the size of the pipe with its limiting safe working strength; the number and location of pumping stations, and whether single or double stage, etc. All depend upon the conditions applying to the particular problem in hand. The fundamental principles upon which a line must be planned are those expressed by the pipe line and horsepower formulae already given, a fact which seems to the author to justify the space devoted to them.

107 In order to secure the greatest economy in design it is necessary to study the effects of the various factors involved in any given case, for there exists a certain relationship among pressures, pipe diameters and number of pumping stations that will give the maximum of economy for any given output and distance of transmission.

108 As a general rule, it is desirable to design the system for the maximum safe working pressures that the pipe will stand, for the reason that high pressures demand smaller pipes, and usually the pipe line is the heaviest item of cost of a system. High pressures, however, mean more power necessary in the compressor stations, with correspondingly increased cost of pumping the gas, thus partially, or perhaps completely, counteracting the lower cost of the smaller lines due to such high pressures. Line leakage is also much more serious the higher the pressure, and on this account it is neces-

sary to make the safe working pressure limits of the pipe line much lower than would be indicated by testing a single joint of the pipe alone.

109 The quantity of gas to be delivered also has a marked influence on the economical number of stations to be used, for the power necessary to pump it is directly proportional to the amount of gas pumped, and therefore the operating and first costs of stations likewise, whereas the size of the line, under the same pressure conditions, increases as the $\frac{3}{8}$th power of the quantity. Consequently, the greater the quantity, the greater will be the relative cost of power equipment over that of the line.

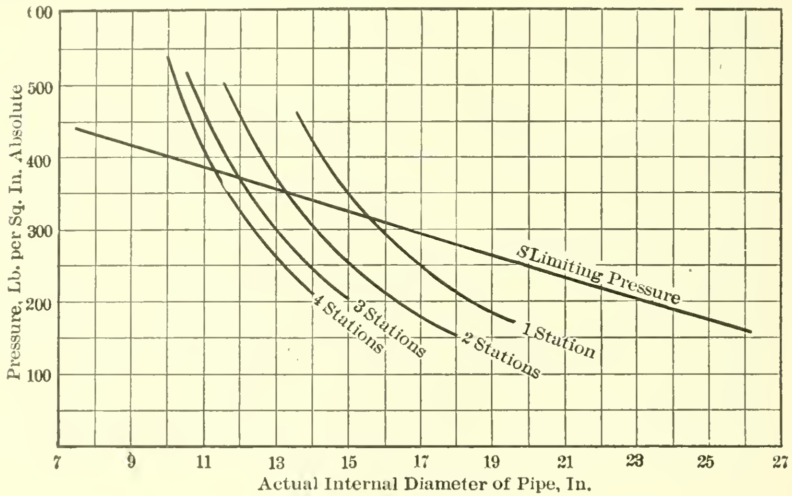


FIG. 10 PIPE DIAMETERS FOR INITIAL LINE PRESSURES FOR INSTALLATIONS OF FROM ONE TO FOUR STATIONS

110 Relay stations between the field and the delivery point should always be single stage only, for it requires the same amount of power to compress the gas through the first stage, say from atmosphere to 53 lb. gage, as it does through the second stage from 53 lb. to 300 lb., whereas practically no benefit is derived in the line for the expansion from 53 lb. to atmosphere, as compared with that from 300 to 53. This is seen from the pressure factor in the pipeline formula.

111 In order to illustrate the effects on the problem of the various factors involved an example is worked out and plotted. It is assumed that the average daily delivery of a transmission system

during the coldest day is to be 24,000,000 cu. ft., or at a rate of 1,000,000 per hour. The transmission distance is to be 300 miles and it is required to determine the pressures and size of line as well as the number of pumping stations required. For the purposes of the example it is assumed that the total power installed will be equal to that determined by the formula without allowing for reserve capacity, and that the actual pipe diameters are used as derived, without regard to standard sizes. The cost of pipe line is taken as $900 per mile per inch of diameter, and the cost of compressor stations at $100 per compressor horsepower installed. Interest and depreciation on the line are taken at 10 per cent and on the power stations at 12 per cent, while operating costs are figured at $15 per year per installed compressor horsepower. The minimum allowable delivery pressure at the end of the line, where it feeds into the distributing system, is assumed as 50 lb. absolute, while the gas from the field is supposed to enter the compressors at 15 lb. absolute, or about atmosphere.

112 First, assuming one station in the field to pump the gas the whole distance, the required pipe diameters are figured for different initial line pressures by means of the pipe-line formula, equation [13]. These different values of pressure and diameter are then plotted as shown in curve 1, Fig. 10. In this figure the limiting safe pressures for various sizes of pipe line are also shown by the line S, and it is seen that this line and that of the required pressures cross each other. For any diameter less than that indicated by the intersection of line S with curve 1, the pressure would be too high for safe working and this point therefore indicates the minimum diameter and the maximum initial pressure that can be adopted with one station.

113 On the basis of the minimum diameter thus derived, the cost of the line is computed, and from the maximum pressure the power required to pump the gas is determined by means of the horsepower formula, using the proper value of suction pressure. From these computations the yearly cost is determined for a single-station equipment.

114 Then an intermediate station is assumed to be located midway of the distance. In computing the relative pressures and diameters it is first assumed that the intermediate station will pump through a single stage of 3.5 compressions, corresponding to the point of maximum compression efficiency as shown in Fig. 8. Under this assumption the terminal pressure of the first section of line is

$$P_2 = \frac{P_1}{3.5} = 0.2855P_1 \quad \text{and } P_1^2 - P_2^2 = 0.9184P_1^2$$

With this value applied to the pipe-line formula the initial pressure for the field station is computed, assuming it to be the same for both stations. This causes the intermediate discharge pressure to be

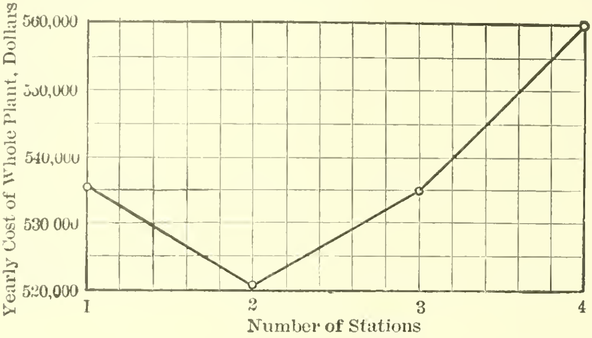


FIG. 11 CURVE SHOWING YEARLY COSTS AGAINST NUMBER OF STATIONS

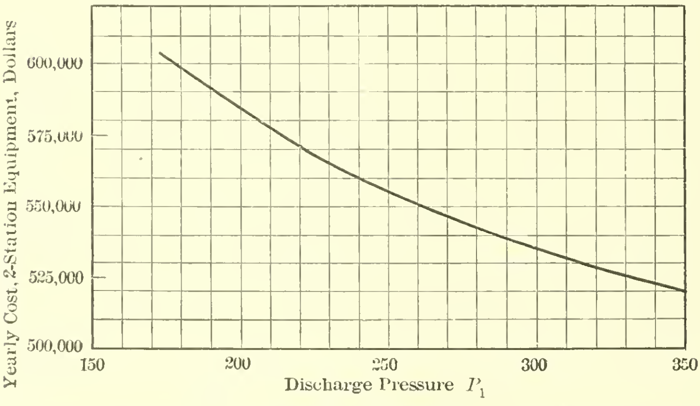


FIG. 12 CURVE SHOWING HIGHEST SAFE PRESSURES GIVING MAXIMUM ECONOMY

slightly higher than would actually be required to transmit the gas through the last section of line with its terminal pressure at 50 lb., but the increase is small, and the method insures the field station discharge pressure being at the proper value.

115 Values of pressure and diameter are plotted and the minimum diameter and the maximum pressure available are taken from the plot as before. The h.p. per 1,000,000 ft. of gas at the intermediate stations will then be constant at 70 h.p., corresponding to 3.5 com-

pressions, but the power of the field station must be figured for its proper ratio of compressions.

116 In the same manner the yearly cost is figured for three and four-station installations, and it is seen from Fig. 11, which is a plot of yearly costs against the number of stations, that for this particular case the lowest cost is attained with but two stations.

117 Figures made with all the conditions the same except that twice the quantity of gas is to be delivered, will show that a one-station equipment furnishes the most economical arrangement. Likewise with smaller maximum quantities to be delivered through the same distance, it can be shown that a greater number of stations, with correspondingly higher pressures and smaller line will result in the maximum economy.

118 Assuming the two-station layout and figuring yearly costs with decreasing initial line pressures, the curve in Fig. 12 results, showing that for this particular case the highest pressures safe to use give the maximum economy.

119 Having thus ascertained the most economical arrangement, it is necessary to consider the question of storage capacity, and see that when the line is packed the pressures and line sizes are adequate to provide sufficient storage gas to take care of the peak load.

120 If this is done for the example chosen it will be found that when the light deliveries are taking place at night the terminal pressure will back up to such an extent that with the intermediate station discharge pressure remaining constant the line will fill with gas to such an extent that more than sufficient storage will exist in the line. This illustrates one distinct advantage of large lines, especially at the terminal end of a system, where the gas can be stored at high pressure near the point of delivery and thus make it possible to draw on the reserve supply on short notice.

STATION DESIGN

121 In many natural gas fields, the natural pressure of the gas is sufficient to carry it to the market. The pressure declines, however, as the gas is withdrawn from the pools, and eventually a point is reached when it is necessary either to build more pipe lines to carry the gas, or to install pump stations for raising the pressure sufficiently high to make the existing lines serve. The principles already set forth will govern the choice in such a case. Usually, however, the pump station will be found preferable, for the reason that the assured continuance of the decline of pressure will eventually

result in the necessity for a station in any event, and, if installed in the beginning, it can readily be adapted to suit changing conditions.

122 Since the volume of gas increases as the pressure diminishes, the size of line necessary to convey a given quantity must increase likewise. Also the pressure drop becomes great under low-pressure conditions. In order, therefore, to make the work of the compressors effective in producing a pull on the wells without excessively low suction pressures at the station, it is necessary to have the stations located as near the center of the field as possible, thus reducing the length of suction lines to a minimum. A few miles added to the length of the discharge line mean almost nothing compared with their effect on the suction side. The location of compressor stations, therefore, means not only a study of the conditions relative to water supply and accessibility, but also of probable future developments in the gas production.

123 While passing, it is well to call attention to the necessity for the utmost care in making all suction lines absolutely tight to avoid the possibility of air entering them, and thus endangering the entire system, as well as impairing the service.

124 The type of compressor in general use for natural gas compression is the ordinary form of reciprocating air compressor. It must be equipped with automatic, or "voluntary," discharge valves, due to the fact that the expulsion of gas from the cylinder begins at differing periods of the stroke, depending on the compression ratio. The most satisfactory suction valve is likewise of this type, although mechanical suction valves have been tried with varying degrees of success. Because of the varying ratios of compression usually encountered, it is advisable to keep the clearance space in compressors as small as possible, for the higher the compression range, the lower will be the volumetric efficiency.

125 The design of the station units involves not only an assumption of the volume of gas to be pumped, but also the determination of the maximum discharge pressure to be demanded of the compressors.

126 The quantity of gas is usually estimated from a consideration of the expected demand for it, as well as a knowledge of the available supply. In most fields there are two general classes of wells, designated as "high pressure" and "low pressure," the former usually being the new ones with natural pressures sufficient to permit them to feed into the lines "ahead" of the pumps, that is, into their discharge lines. The latter, or low-pressure wells, are those that

require pumping. Frequently there are wells with pressures too low for feeding into the high-pressure discharge, but sufficiently high to feed the suction of the high-stage pumps, and by proper systems of piping, this is usually provided for. This naturally affects the station design, as it necessitates the pumping of more gas through the second stage than through the first, and proper provision must be made for it by the addition of the requisite number of high-stage units.

127 No fixed value of discharge or suction pressures obtains in the operation of any natural gas pumping station. The variation in these pressures throughout a single day may cover a wide range of limits, while it is especially marked from day to day throughout the year. In this respect the compression of natural gas differs widely from that of air under the usual conditions, and presents several additional problems not encountered in the compression of air. As relates to the question of design, this factor determines not only the power necessary to drive the compressor but also the quantity of free gas a machine will handle, and involves what is termed the peak-load condition of power requirement, as was shown in the development of the power formula. While it is well to provide for ample power to drive the compressors under all conditions of operation, the principle is easily carried to absurd limits, with the ultimate result of great loss in volumetric output. In some instances it is found necessary to pump gas with compression ranges varying from two to five or six. Under these conditions the unit must be designed to carry the load over the peak, and it will then operate under any and all conditions of suction pressure, with the discharge at its proper value. Usually, however, this will not be necessary, and then the upper limit of suction pressure may be estimated, and, if on occasion it should greatly exceed the value for which the units were designed, it can be reduced by throttling the gates on the suction lines.

128 The discharge pressure to be used in designing the compressor cylinders must be that of maximum condition, which is usually at night when the lines are being packed, or stored, with gas to provide sufficient storage capacity to help over the peak load conditions in the distributing system.

129 While this maximum pressure must be used to determine the engine power required, the ratio of cylinder sizes for two-stage compression must conform more nearly to average load conditions, in order properly to equalize the work between the two stages for average conditions of operation. Once the cylinder diameters are fixed, the ratio of discharge to suction pressure of the low-stage unit,

or, in other words, the ratio between the high and low-stage suction pressures, will be practically independent of the high-stage discharge pressure. The ratio of cylinder diameters may be determined as follows:

130 Let

V_1 = the volume of low-pressure cylinder per revolution
D_1 = diameter of cylinder
d_1 = diameter of piston rod
s_1 = stroke
n_1 = speed, r.p.m.
e_1 = volumetric efficiency
P_1 = absolute suction pressure
T_1 = absolute suction temperature

and let the corresponding letters, with sub h, apply to the high-stage compressor. Also, let P_o and T_o be the absolute pressure and temperature of any base on which the gas may be measured. Then the actual quantity of gas pumped per minute referred to P_o and T_o will be

$$Q = V_1 \frac{P_1}{P_o}\frac{T_o}{T_1} e_1 n_1 = V_h \frac{P_h}{P_o}\frac{T_o}{T_h} e_h n_h \ldots\ldots\ldots\ldots [54]$$

since all the gas that passes through the low-stage cylinder must be pumped through the high. Hence

$$n_1 V_1 e_1 \frac{P_1}{T_1} = n_h V_h e_h \frac{P_h}{T_h}$$

$$\frac{P_h}{P_1} = \frac{V_1}{V_h}\frac{e_1}{e_h}\frac{T_h}{T_1}\frac{n_1}{n_h} \ldots\ldots\ldots\ldots [55]$$

But

$$V_1 = \frac{\pi s_1}{4}\left(D_1^2 - \frac{d_1^2}{2}\right) = \frac{\pi s_1}{8}(2D_1^2 - d_1^2)$$

and

$$V_h = \frac{\pi s_h}{8}(2D_h^2 - d_h^2)$$

Hence

$$\frac{P_h}{P_1} = \frac{s_1}{s_h}\frac{(2D_1^2 - d_1^2)}{(2D_h^2 - d_h^2)}\frac{e_1}{e_h}\frac{T_h}{T_1}\frac{n_1}{n_h} \ldots\ldots\ldots\ldots [56]$$

Assuming the same speed and stroke for both stages,

$$\frac{P_h}{P_1} = \frac{(2D_1^2 - d_1^2)}{(2D_h^2 - d_h^2)}\frac{e_1}{e_h}\frac{T_h}{T_1} \ldots\ldots\ldots\ldots [57]$$

131 From equation [57], it will be seen that the ratio of suction pressures in the two stages depends upon the net cylinder areas, the volumetric efficiencies and temperatures of the suction gas.

132 If the intercooling is inefficient, T_h will exceed T_l, and the discharge pressure of the low-stage compressor ($=P_h=$the high-stage suction) will be raised, thus imposing more work on the low-stage units. Usually, however, adequate cooling can be attained,

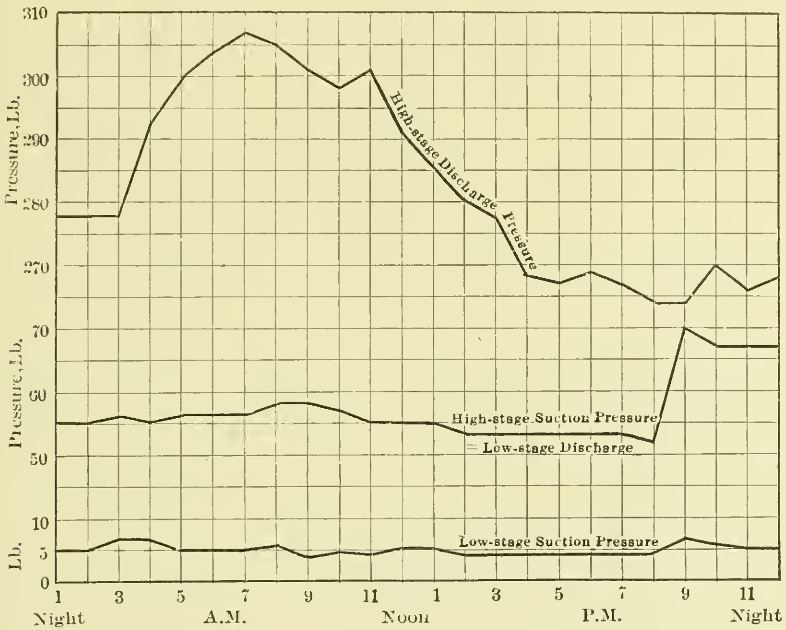


FIG. 13 CURVE SHOWING HOURLY PRESSURES OF TYPICAL PUMPING STATION FEEDING INTO A LINE 120 MILES LONG DURING AN AVERAGE WINTER'S DAY

and the ratios of temperatures may therefore be taken as one. Under this assumption the compression ratio in the low-stage cylinder becomes equal to the ratio of net effective areas of low to high-stage cylinders, that is, the computed areas multiplied by the respective volumetric efficiencies.

133 The ratio of the diameters of the high and low-stage cylinders can therefore be determined from equation [57], having fixed upon the proper ratio of compressions for each stage, as determined by average operating conditions.

134 In order to illustrate the fact previously stated, that the high-stage suction pressure is practically independent of its dis-

charge, Fig. 13 is given, showing a plot of the hourly pressures of a typical pumping station feeding into a line 120 miles long during an average winter's day.

135 The size of compressor cylinder required depends upon three things: the quantity of gas to be pumped, the suction pressure at which it can be supplied to the compressor, and the speed of the compressor.

136 The first of these requirements must be ascertained from the number of units to be installed, and, in this particular, there seems to be a considerable difference of opinion among engineers. The author believes that there should be a sufficient number of units, so that in case of a shutdown of any one of them, the capacity of the plant would not be seriously impaired. In fact, it is distinctly the part of wisdom to provide one spare unit over and above the actual requirement under the most severe conditions. Natural gas compressors, unlike most other power apparatus, cannot have their capacity forced, for there are only two means of increasing it, namely, by increasing the speed, which has a well defined upper limit, and by raising the suction pressure; and usually, when the greatest demand is made on the plant, the field is supplying all the gas of which it is capable, and thus it is impossible to add to this pressure. Natural gas companies are, as a rule, public service corporations, and it is absolutely necessary to maintain the operation of the stations continuously during severe weather in order to prevent great suffering.

137 Having given the quantity of gas to be pumped and the suction pressure, the required size of the cylinder is readily computed when the proper value of volumetric efficiency is assigned.

138 In good modern compressors of large size and long stroke, the indicated volumetric efficiency may range from 98 per cent to 90 per cent, depending upon the ratio of compressions, and the slippage loss will range from 3 per cent to 10 per cent, so that it is not unusual to find actual volumetric efficiencies as high as 94 per cent. In the majority of cases, however, the actual efficiency will range from 80 to 90 per cent, with 85 as a fair average for working conditions.

139 The constantly growing demand for compressors of high efficiency for natural gas compression has given a considerable impetus to improvements in design, which have resulted in lower clearance spaces and improved valves and jacket cooling, and it is entirely reasonable to specify volumetric efficiencies of 90 per cent, or even higher, with units of large size.

140 When the actual volumetric efficiency of a unit is known, its pumping capacity can conveniently be determined from the formula:

$$Q = 0.000909 \times E \times s \times \left(D^2 - \frac{d^2}{2}\right) \frac{NPT_o}{P_o T} \quad \ldots\ldots\ldots [58]$$

where

Q = output, cu. ft. per min.
E = volumetric efficiency of compressor
s = stroke, in.
D = compressor cylinder diameter, in.
d = compressor piston diameter, in.
N = revolutions per minute
P = suction pressure, lb. per sq. in. absolute
T = suction temperature, absolute
P_o = pressure base of gas measurement, lb. per sq. in. absolute
T_o = temperature base, absolute

141 This formula assumes that the compressor has no tail rod. Should it have one, the value in the parenthesis would have to be modified to suit. From the formula the diameter necessary for any given capacity can be computed by substituting the known quantities in the equation.

142 Usually the temperature of the suction gas is assumed to be the same as that of the measurement basis in stating the capacity of a compressor, and hence the factor $\frac{T_o}{T}$ in the formula is dropped, being equal to 1.

GENERAL REMARKS

143 The problem of the number of compressions to use in the determination of the power required is usually more or less indeterminate and requires the exercise of the judgment of the engineer in each particular case, based upon a knowledge of the field pressure conditions and the probable discharge pressure as already discussed. The discharge pressure is, as shown, a matter of computation, but the suction pressure may vary widely under different conditions.

144 Compressors for natural gas were originally driven by steam engines, but, owing to the recent improvements in the design and reliability of large gas engines, and to their high economy, this type of prime mover is rapidly supplanting the steam engine. Usually

the compressor is direct-connected to the engine, although there are many successful installations using the belt drive. Motor-driven units are rare however.

145 The tendency in recent years has been to lay gas transmission lines with rubber-packed sleeve couplings, in sizes above 4 in. In fact, it is imperative with lines above 10 in. in diameter, owing to the difficulty of making tight screw-collar joints with the larger sizes of pipe. Lines are usually designed for pressures as high as the pipe will stand, sometimes exceeding 400 lb. per sq. in., and, inasmuch as the leakage is a function of the pressure, irrespective of the quantity of gas flowing through the line, it is essential that the pipe joints be made as tight as possible.

146 In using the sleeve type of coupling it must be remembered that it offers very little resistance to end thrust, and proper provision must be made for anchoring the pipe wherever it deviates from a straight line, such as making turns or going over the crest of a knoll.

147 Heavy fittings are usually necessary, not only to stand the gas pressures, but also to provide against the enormous strains produced by expansion and contraction due to temperature changes and to frost. This is especially true at compressor stations because of the high temperatures due to compression, which sometimes reach 300 deg. to 350 deg. fahr. At these stations it is usual to provide swing-joint connections; all stiff joints should be avoided, especially where any considerable length of pipe is involved.

148 Owing to the possibility of leakage gas accumulating in a pump station and endangering the plant, it is necessary to provide adequate ventilation. The method favored by the author is to have the pump house equipped with a monitor, and a fan installed in the auxiliary building, which draws its supply of fresh air from outside, over the hot gas engine exhaust pipes which are laid in a conduit in the pump house. The air is then forced back into the pump house, thus providing both heat and ventilation without the necessity of auxiliary boilers or fires about the premises.

149 All buildings must be lighted by electricity, the generator being installed in the auxiliary building. This generator is usually of the direct-current type in order to provide current for charging the storage batteries generally installed for ignition purposes. The auxiliary building should be from 30 to 40 ft. away from the main pump house in order to lessen the risk of explosion.

150 All electric lamp sockets in the main pump house should be

of the keyless type, and all electric switches should be enclosed. Care should be taken to exclude any pockets under the pump-house floor or elsewhere where gas might collect.

151 In piping up gas compressor cylinders it is strongly advisable to provide a by-pass for use in starting, especially with gas engine driven units; and also an automatic safety valve, connected to the discharge pipe between the compressor cylinder and the first gate. There have been several instances where compressors have been destroyed by attempting to start with a closed discharge gate, and this precaution is most necessary. Such relief valves should have ample capacity to pass all the gas the compressor might discharge, and should be tested at regular intervals to insure their being in an operative condition at all times. They are fully as important as a safety valve on a boiler.

152 Two-stage pumping stations should be provided with both inter-coolers and after-coolers, which are usually composed of networks of pipe immersed in a pond or reservoir adjoining the station. Drips should be connected at the discharge end of all coolers, in order to collect and dispose of the gasolene which usually is produced by the process of compressing and cooling natural gas.

153 These drips are sometimes provided on an elaborate scale, where it is found that the gasolene production is sufficiently large to warrant collecting and selling it, and in some cases refining plants are installed for rendering the gasolene fit for the market.

154 It is important to extract all of this gasolene from the lines, as otherwise it will collect in depressions and "freeze," completely plugging the line. The secret of getting out the gasolene is so to build the after-cooler as to cause the flow of gas to be greatly retarded, when the liquid may be extracted by proper separators.

155 By-pass connections should be provided around the coolers in order to enable the plant to discharge its gas direct into the lines in case of leakage in the coolers.

156 All station piping should be "flexible," so as to permit operation with various systems of connection, and should be arranged in such a manner that the plant can be tested with ease.

THE EFFICIENCY OF CONTROL SYSTEMS IN FLYING MACHINES

At the meeting of the Society held in Boston on February 16, 1912, a paper was presented by Albert A. Merrill[1] on The Efficiency of Control Systems in Flying Machines.[2]

The first question to be considered is the movement of the levers connected with the control surfaces. The movement of these levers should be instinctive, that is, they should be such as one would make without being taught. To lower the front of the machine the lever should be moved forward, to raise the front it should be moved backward. This is done in all machines and there is never any danger of making a false movement with the fore and aft control. When the machine tips laterally, the lever should be moved towards the high side as, when tipping over, it is instinctive to move towards the high side.

In many machines this method is used, but in some, notably in the Wright machine, lateral control is obtained by a fore and aft movement of the lever. It can not be considered the best system, however, since it is not an instinctive motion and when placed in a dangerous position a man might not make the correct movement. The Wrights use this system because it requires considerable pressure to warp the wings of their machine and more pressure can be delivered by the arm with a fore and aft motion than with a lateral motion. However, the work of the Farman and Curtiss machines shows that ailerons will maintain lateral stability as well as warping wings, and as it takes but little pressure to move ailerons a lateral motion will give all the pressure needed.

Let us consider the aerodynamic efficiency of control surfaces in reference to the lift and drift of these surfaces. By lift is meant that component of the normal pressure at right angles to the line of flight, and by drift, that component parallel to the line of flight.

[1] Brookline, Mass.

[2] Published in abstract only. Complete report may be consulted in the rooms of the Society.

If two curves are drawn representing the lift and drift of a plane surface at all angles from 0 to 90 deg., it will be found that the lift component increases rapidly from 0 to about 20 deg., slowly from that angle to about 35 deg. and then drops rapidly to nothing at 90 deg. The drift component on the other hand increases constantly from 0 to 90 deg. These two curves show that the maximum pressure that can be given by a surface is its drift at 90 deg. Moreover, only at small angles can its lift be utilized efficiently, since with an increase of the angle, the drift increases, and this drift tends to reduce the total lift by reducing the speed. *It follows therefore that all control surfaces should be placed where their drift can be utilized.*

The first practical application of this is to the rudder. As now placed at the rear, only the lift component is used for turning, the drift component acting as a drag and retarding the speed of the machine and consuming power. The place for the rudder is not at the rear, but at the tips of the wings, because when placed at the tips, both components are utilized. In this position, the drift component turns the machine and the lift component tends to prevent skidding, thus reducing the required angle of banking. Rudders thus placed will satisfy the requirement that control surfaces should be placed where their drift can be utilized.

The three common systems now in use violate the requirement regarding control surfaces as just stated. The Wright system consists of means for increasing the positive angle of the wing to be raised, decreasing the positive angle of the wing to be lowered, and turning the rudder towards that wing, having the lesser angle of incidence. The Farman system consists in increasing the positive angle of an aileron on the wing to be raised and turning the rudder towards the other wing. The Curtiss system consists in increasing the positive angle of an aileron on the wing to be raised and turning not the rudder, but another aileron on the other wing to a negative angle so as to produce the necessary offsetting backward pressure.

The point common to all is that the positive angle of the wing or aileron, which it is desired to raise is increased and a backward pressure on that wing or aileron thus introduced. This backward pressure of course reduces the speed of the affected side, and unless the speed of the other side is reduced equally, the side desired to be raised will fall. It follows that in these systems the control surfaces are placed in such a position that the drift can not be utilized but must be offset, which offset is made either with a rudder or another

aileron. It is well to remember that pressures vary as the square of the speed and that a change of angle has little effect on lift compared to the effect of a change of speed. Thus if the angle is doubled, say a change from 4 to 8 deg., an increase of lift of only 27 per cent will result; but if the speed is doubled, four times the lift is obtained. It follows therefore that the difference in speed between the wing tips is of more importance than the difference in the angles of incidence. Broadly speaking, the three systems referred to are similar and all three are inefficient in so far as they introduce a force, drift, which can not be used but must be offset.

The error lies in attempting to raise the wing. It is impossible to do this without introducing drift, which antagonizes the lift component. When a flying machine loses its lateral stability nothing should be done to the low side, all attention should be devoted to the best way of introducing a downward and backward pressure on the high side. This can be done in a way which is exactly the reverse of the Farman system: Have the ailerons movable only to a negative angle and only on one side at a time, then always move the aileron on the high side. This is the simplest possible system, both mechanically and aerodynamically; the lift component will be downward and will lower the wing directly, while the drift component can be used because it comes on the high side and will retard, and hence lower, that side. The drift is used, no offset is needed, and moreover, there is no danger from over-control because, no matter how large a drift is introduced, from too great a movement of the aileron, it always helps to produce the desired result. This is not true of the drift component of the other systems. The writer feels sure that in time a system of control based upon this principle will drive out all other systems, for it is essential to stability systems that no force which can not be used shall be introduced.

Turning now to the question of fore and aft control and starting with the fundamental lift and drift curves, if a horizontal line is drawn at that point where the drift equals the thrust, and a new lift curve computed, assuming the thrust and hence the drift constant, but the angle increasing it will be seen that the lift drops off very rapidly with every increase in the angle of incidence. From this new curve three angles show important data: the minimum flying angle, which is the lowest angle at which the machine will fly; the climbing angle, which is the angle at which the machine will climb most rapidly; and the stalling angle, which is the maximum angle at which the machine will fly. Safe flying means that the angle of incidence must

be kept between the minimum and the stalling angles and since with any but the highest powered machines the difference between these two angles is small there is constant danger of stalling and having an accident. For this reason one ought always to have a good clinometer on the machine so as to know at a glance his flying angle. Except for this danger of stalling, fore and aft stability seems to be easier to maintain than lateral stability, partly because when lateral stability is lost the machine may start sliding sideways and this introduces very grave dangers.

Many inventors have proposed to use vertical surfaces to prevent this sliding, others have proposed the use of the dihedral angle, but to all such proposals there is a fundamental objection, which is that such systems do not begin to work until the machine has already begun to slide, whereas a control system should anticipate the action it is designed to prevent.

To sum up then the three important points regarding control systems: first the lever should be moved towards that part of the machine it is desired to lower; secondly all control surfaces should be placed if possible where the drift component can be utilized; and thirdly a control system should anticipate the action it is desired to prevent.

FLOUR MILLING AND MILL ENGINEERING

At the meeting of the Society held in Philadelphia, March 30, 1912, a paper was presented by B. W. Dedrick, instructor of milling and mill engineering, Pennsylvania State College, State College, Pa., on Flour Milling and Mill Engineering.[1]

The ancient builder of mills was called the millwright, and, even up to comparatively modern times, was the only person capable of designing, building, and placing machinery and planning buildings for their accommodation, not only of flour mills, but factories or whatever machinery was employed.

The modern flour mill building does not depart radically from other buildings designed for the reception and operation of heavy machinery, but the height of building and floors is given more consideration. Mill buildings are usually carried up three, four, five or more stories above the basement. It is necessary and better economy to have sufficient height in order to place certain machines one above the other, so as to take advantage of the force of gravity in the handling of stock. In designing mill buildings, the engineer must also take into consideration the great weight to be supported, not only of the heavy and numerous machines required and their driving connectors, spouts and bins, but of the grain and flour that is kept within the building. Besides, in the modern mill nearly all machines used are rapidly revolving, and if improperly placed or balanced, are particularly hard on a building, causing a perceptible weaving motion or tremor. The floors have to be of proper height to give sufficient pitch or incline to spouts, for if the spout is too flat or of insufficient pitch, the flour or other material will not run down, but choke or clog. The flour mill building, especially on the grinding and bolting floors, should be well lighted by a sufficient number of windows in day time, and electric or other good light at night, for it is necessary frequently to inspect the flour and other stock, and a good steady and bright light is absolutely essential to detect the extremely close shades in the color of flour, and compare it with the standard samples.

[1] Published in abstract only. Complete report may be consulted in the rooms of the Society.

Practically the first step of the wheat in the mill is in the separators, of which there are usually two: the receiving, that rough cleans the grain as it comes into the mill, taking out straws, wheat heads, sticks, oats, seeds and other trash; and the milling separator, that handles the wheat, cleaned almost entirely of foreign matter, making a closer and finer separation of the wheat, taking out any remaining oats, white caps, joints and seeds left over by the receiving separator. The light and imperfect wheat is drawn out by air current. From the separators the thoroughly cleaned wheat goes to the scourer which has a cylinder or series of blades or beaters revolving very rapidly, from 500 to 700 revolutions. These beaters throw the grain against the "case" which may be simply of heavy woven wire, the mesh or openings being small enough to prevent even the smallest berry from passing through, but allowing pieces of bran, chit or seed to be forced through, to settle in the hopper below, or to be drawn into the fan.

The effect of the beaters throwing the wheat against the rough casing at varying angles is to scour off the beards, exterior dirt and, in case of severe scouring, the outside cuticle or woody covering, all this being forced through the openings of the case, with the beaters acting as blowing fans. In both cases of the separator and scourer, the wheat is subjected to a current of air or suction at the receiving end and again on leaving the machine; this takes out the lighter wheat and remaining dust. On their passage to the fan, the heavier grains are arrested when they get into the tips where the expanding air loses some of its force, and cannot carry them farther, so they fall of their own weight into what is called "the screening tips." In some mills wheat that contains a great deal of cockle seed is passed through a cockle-cylinder which removes seed more perfectly. Mills that use wheat containing a good deal of smut or contaminated by smut, wash the wheat in machines for that purpose, after which it is dried and again scoured and tempered before going to the rolls.

A modern roll called a "double stand" consists of two pairs, one on each side. If each pair handles different material as they do in smaller mills, a partition below the rolls practically makes each a distinct pair.

The rolls are carried on bearings, which are rigid for one roll and movable or free for the other, allowing this roll to be adjusted closer to or further apart from the other roll according to the fineness desired to break or crush the stock passing between the rolls.

The arms of the movable roll are pivoted below on eccentric bearings, one on each side of the roll frame. The tramming or bringing the rolls into level is accomplished by means of turning this eccentric bolt, and then locked by a nut, but the arm is allowed to move or swing freely as in adjusting the rolls or spreading them apart, by the lever, when shutting down or when the roll runs empty. The arm at the top carries a recess which contains a heavy coil spring, which bears against the inner closed end, and against the wheel at the outer end. The rod passing through is the adjusting or lighter, corresponding to that of the millstone. At the outer end is the hand wheel used to compress the spring and thus stiffen or increase the tension. The inner hand wheel is the adjustor. By turning the wheel left or right, or forward on the threaded rod, it permits the rolls to close up; turning it in the opposite direction, spreads the rolls apart. Passing through the center under the feeder housing is a small shaft to which is attached a lever. There are two pairs of eccentrics on each end, to which are attached the adjusting rods by their yokes. The movement of the lever in one direction throws both the movable rolls from their mates simultaneously at both ends, and vice versa, brings them back to position.

Each pair of rolls has a fast and slow roll. In order to grind or crush with effect, there must be more or less of a rending or tearing action, and for this reason the rolls are given "differentials" in speed, the most common differentials used being $2\frac{1}{2}$ to 1 for break rolls on wheat, to $1\frac{1}{2}$ to $1\frac{1}{4}$ to 1 on the middling reduction rolls, which are smooth almost without exception, though very finely corrugated, or scratch rolls are sometimes used on the first clean middlings.

There are several types of bolters or sifters. The hexagon or six-sided reel is the oldest type of bolter still used, but its action in bolting is rather harsh. The round reel dresser is gentler in action, and like the hexagon, is slow in running, 30 revolutions being the mean. The centrifugal reel is used only on very soft, flaky material, for its disintegrating effect. The gyrating type of sifter is altogether considered to be the best and most gentle of all. The action of the gyrating sieves is to compel the stock to travel spirally on the surface of the flat sieve and on top of the silk, so as to bring the lighter, fluffier and impure parts on top of the traveling stream and hold them there until they tail off, the purer going through the cloth. Various means or devices are used to keep the meshes of the cloth open.

From there the wheat goes to purifiers. In the old flat grinding process all the flour possible was made at one and the first grinding. This system was very simple, consisting of a rolling screen, a smutter, a pair of burrs, one or two long reels, and a couple of elevators. Some middling or semolinas were made, but of such a character and containing so much fine bran or germs that when these middlings were reground on stone and bolted, it made an inferior flour as compared with the first, or superfine, produced in the grind of the wheat itself. The invention of a successful middlings purifier changed all that. From seeking to grind low, making no middlings or as little as possible, it now became the object to grind higher, cut the bran as little, and make as much middlings as possible. The miller reduced the feed on the stone by half, bestowed more skill and patience in dressing the burr, giving smoother surfaces and grinding higher and cooler with a millstone; he thus produced middlings that after being purified and then ground separately on stones and bolted, made flour superior to the "first" or "clear" flour produced from the grinding of the wheat itself. This flour produced from the purified middlings was called "New Process" or "Patent" flour.

The different grades of middlings, after being purified, are crushed on the smooth rolls and then sent to different sections of the sifter and sometimes to reels, as in the last roll reduction. With each reduction and subsequent separation of bolting, there is a certain amount of flour sifted out, and as a natural consequence there is an increased proportion of impurities to be handled on the next reduction and separation, so that the tendency is for the flour to be less white and clear, and partially to counteract this tendency it is necessary to have the cloths finer and finer. After certain reductions the tailings may be of such a nature as not to require further handling, and are sent direct to feed as finished, while those containing any floury parts are again reduced and sifted, the final results being flour, bran and shorts.

The paper contained also a detailed discussion of the capacity of machines and weights, and a description of the model mill to be built at Pennsylvania State College, State College, Pa., to give students the practical part of milling, and for experimental purposes in the way of testing the different kinds of wheat, to ascertain the bread making qualities of the flour; baking and chemical tests of flour and grain, and experimentation with various machines as to efficiency, power absorbed, etc.

DISCUSSION

In the discussion which followed, Mr. Wilson W. Welsh gave some reminiscences of Philadelphia milling in the early sixties, including a list of mills in existence at that time. Philadelphia of today has lost its former prestige as a milling center. From the early sixties the West was growing and built new mills, and was adopting all the latest improvements, while the eastern mills held back. The result was that theWest gained control in the eastern markets, and not until within the last twenty-five years did the Eastern millers wake up to the fact that they must keep pace with these improvements in order to retain their markets or draw even a small share of the business. The failure to adopt the improvements as they came forward was the cause of the decrease of milling in the East, not only in Philadelphia, but throughout the states of Pennsylvania, New York and Maryland. Now the situation has changed, the Eastern millers are alive to the necessity of adopting improvements, and are gaining ground.

Prof. J. P. Jackson drew a parallel between the development of the study of metallurgy and that of the production of breadstuffs. Five or six years ago it seemed as if we had reached the limit in the production of iron and steel in the quality of material, but the study of metallurgy went ahead, and today it looks as though we are only at the starting point. In the study of the production of foodstuffs this country has fallen behind Germany, but is going to be first again. It seems necessary and desirable to make some center where there would be a radiating influence or source of information from which an advantageous study of milling processes could be carried on, and where a young man could be prepared to go into the mills to work and advance their efficiencies. With regard to industrial training generally, the speaker wanted to see an opportunity for every boy, who was not going to take up professional work, to have a chance to use his hands as well as his brain.

Mr. H. V. White[1] told the story of how he and the Pennsylvania Millers' Association had attempted to secure from the state legislature a grant of funds for putting up the model mill described by the speaker of the evening, and emphasized the importance of such a mill. No one scarcely knows what scientific knowledge is necessary to drive a mill. A man who goes into a large mill today to learn milling is specialized and works in a groove, and may work for a dozen or more years without becoming a miller; he learns but one side of that work, and only few get down to the mechanics of milling.

[1] President, Pennsylvania Millers' Association.

FOREIGN REVIEW

BRIEF ABSTRACTS OF CURRENT ARTICLES IN FOREIGN PERIODICALS

CONTENTS

FOREIGN REVIEW

The aim of the Foreign Review is to present, within the available space, the main data contained in the articles indexed. Where possible, reference is made to English or American publications containing fuller information on the subject treated. Measures are given both in original units and their English equivalents. In many instances, engravings and tables are reproduced. Opinions expressed are those of the reviewer, not of the Society. Artic les are classified as *c* comparative; *d* descriptive; *e* experimental; *g* general; *h* historical; *m* mathematical; *p* practical; *t* theoretical. Articles of exceptional merit are rated *A* by the reviewer.

Aeronautics

WINDKRÄFTE AN EBENEN UND GEWÖLBTEN PLATTEN. DRAHTWIDERSTAND, O. Föppl. *Zeit. für Flugtechnik und Motorluftschiffahrt*, March 16, 1912. 3½ pp., 10 figs. *eA*. Data of tests on the *action of wind on flat and curved surfaces and resistance of wires* made in the Laboratory for Testing Models at Göttingen, and comparison of these data with those obtained by other experimenters.

MOTORE "EOLO." ANNALI DELLA SOCIETA DEGLI INGEGNERI ED ARCHITETTI, October 16, 1911 (quoted from *Annales des Ponts et Chaussées*, January February, 1912). *d*. This *motor*, invented by Landriani and Carnaghi, *for use in aviation*, consists essentially of a cylinder *C* (Fig. 1) turning around a transversal axis *A* and provided with two pistons *P* enclosing a chamber *S* of variable volume; each piston has a piston rod terminating with a guide-pulley *R* running along a closed curve with center on the transversal axis *A*. If an explosion occur in the chamber *S* when the cylinder is in one of its intermediary positions, the tangential components of the pressures transmitted to the guide pulleys will form a couple which will cause the cylinder to rotate around the axis *A*. If the area of the curve be divided into four quarters, as shown in the figure, the total cycle will consist of admission of the mixture in quarter I, compression in II, explosion in III, and exhaust in IV.

SUR LE GYROPTÈRE, Papin and Rouilly. *Comptes rendus des séances de l'Academie des Sciences*, March 4, 1912. 1½ pp. *d*. Exposition of principles of construction and description of a new type of aircraft. A *gyropter* is a single-screw helicopter in which the fulcrum for the formation of the motor couple is provided not by a second screw as has been usually done, but simply by the resistance of the surrounding air, by means of

compressed air jets, these jets acting on the propeller screw in the same way as steam jets in a wind valve. The principle of the apparatus, and particularly that of the construction of the screw, *has been borrowed from the seed-carrying leaf of the sycamore*, the screw (Fig. 2) being single-bladed, and having its center of gyration practically independent of the speed according to general laws governing the equilibrium of non-symmetrical bodies rotating in space, such as lassos and boomerangs. In this apparatus the center of gyration is located in the car, which is enclosed in the body of the apparatus, supported and guided by it, but at the same time free to preserve its relative immobility, or to have its position con-

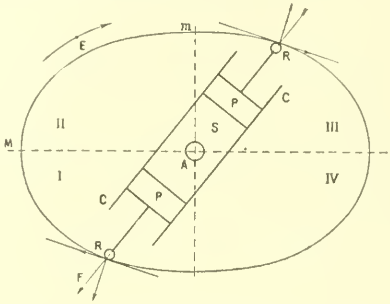


Fig. 1 "Eolo" Aviation Motor

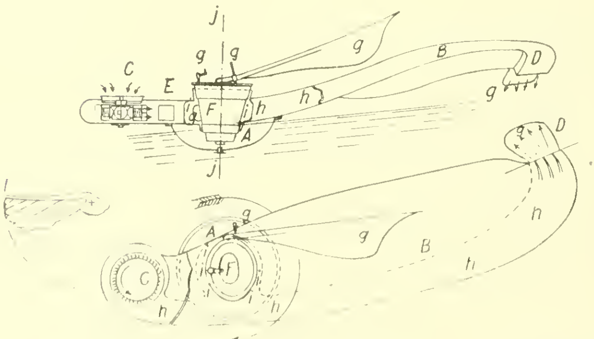


Fig. 2 Gyropter or Single-Screw Helicopter (Constructed on the Principle of a Sycamore Leaf)

trolled by the aviator. Should the motor suddenly stop, the gyropter, owing to its distribution of weight and convenient choice of angles of planes, will automatically take a position such as to produce the slowest possible rate of fall as is done by the sycamore leaf. To rise, a convenient inclination must be produced, while the horizontal progression requires another inclination of the axis of the screw, which acts thus either as an

elevating, or as a driving propeller, or in both capacities at once. The article does not state whether the gyropter has been tested in actual flight, or what the size of the model constructed was.

Hydraulische Höhensteuerung und Stabilisierung der Flugzeuge. Donát Bánki. *Zeits. für Flugtechnik und Motorluftschiffahrt*, March 16, 1912. 3½ pp., 3 figs. *d*. Description of a new *hydraulic stabilizer for aircraft*. The author started with the idea that all stabilizers based on the use of what he calls geodetic direction must be failures because the action of masses produces oscillations which have to be suppressed at the expense of sensitiveness of the apparatus. In Bánki's system of stabilization the whole control is located in the steering wheel, the airship being turned right and left by moving the wheel within the horizontal plane as in an automobile, while by changing the plane of the wheel itself the up and down motion of the ship is controlled: to do this, a system of servomotors is installed, keeping the plane of the ship always parallel to the plane of the steering wheel. There was, however, another difficulty to overcome. When the airship has been tilted by the action, say, of the air current, and the servomotor begins to act to set it straight, the opposition produced by it to the tilting action of the air current will grow until that action is overcome. It will not, however, stop right then, but continue to act, and, as a result, will tend to tilt the motor the other way. Then the stabilizer will begin to act in the other direction, and the process will be repeated, the aircraft meanwhile being subject to more or less violent oscillations. The essential part of Bánki's construction for bringing back the ship into its original position is a lever of which the "three fulcra" are connected with the adjusting gear of the governor, the distributing valve, and the cylinder of the servomotor. These three fulcra, or points, may be designated by a, b and c. When the ship tilts, the governor gear displaces a, and causes the lever to rotate about c, thus bringing the point connected with the distributing valve out of its middle position. This causes the motion of the cylinder of the servomotor and point c, and thus rotation of the lever about the point a. But while a is in motion, b cannot attain its middle position, because it is all the time kept out of it by the rotation about c as an instantaneous center of rotation. But at the instant when the governor gear is at rest, i.e., when there is no tilting of the ship, the lever begins to rotate about the instantaneously fixed point a, the distributing valve comes into its middle position, and the stabilizer ceases to act until it is brought into action by a new tilting of the aircraft.

Fig. 3 shows the construction of the Bánki stabilizer. The servomotor piston *1* is stationary, the liquid being brought in and out through the piston rods 2 and 3. The cylinder 4 moves up and down, is provided with a rack 5 engaging with a toothed segment 6, and thus driving a shaft on which is set lever 16 or a rope pulley. The shafts belonging to the two servomotors, one for longitudinal, and the other for lateral stability, are placed concentrically. The distributing valve is 8, sitting in the distributor case 7, and actuated on by the lever 14. The second fulcrum of this latter is on the cylinder of the servomotor, and the third is connected with the

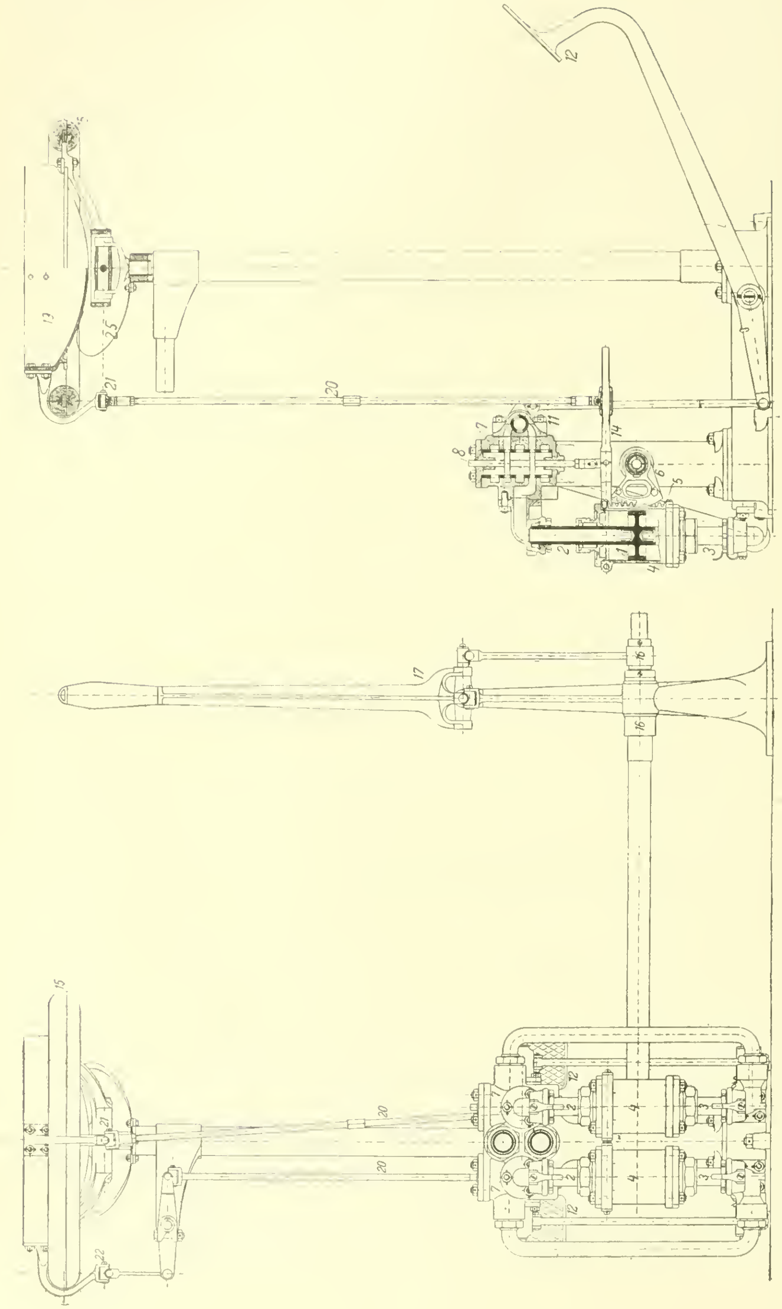


Fig. 3 Bánki Stabilizer for Airships

rod 20 by the disk 19, sitting on the steering wheel, and moving as it moves except in the case when the wheel rotates about the vertical axis. The pedal 12 serves to cut out the servomotor, and leaves the aviator free to maintain his equilibrium in the usual way, by operating the lever 17.

The servomotor could be operated either by air or by water. The inventor chose the latter because water, as a highly incompressible fluid, permitted the apparatus to be more quick-acting and compact. The apparatus has not yet been actually constructed.

Fuel and Firing

Teer-Koksgrus-Unterwindfeuerung, Böndel. *Journal für Gasbeleuchtung*, March 9, 1912. 1½ pp., 1 fig. *d.* Description of a *forced-draft furnace* built by J. Schwartzkopff in Lauban, Germany, *for very small coal and gas tar as fuel.* The furnace has a grate consisting of a plate with nozzle-shaped holes bored through it, the holes being set closer at the coking plate and nearer the fire bridge than in the middle of the grate. An undergrate steam-jet blower supplies a powerful draft consisting of a mixture of steam and air, which cools the grate and raises the temperature of the fire better than a blast of air alone. Of extreme importance is a correct arrangement of the steam-jet blower which can be found only by trying; it was found during tests that even very slight changes in the arrangement of the blower affected the efficiency of the apparatus quite seriously. The volumetric efficiency of the draft was found to be proportional to the steam pressure, and when the steam is dry, saturated steam is better than superheated. It was further found by careful experimenting that a battery of small jets requires less steam for the same amount of work done than one big jet. The tar-burning device is arranged so that the tar flows in a thin stream into the combining nozzle, is there caught up by a steam jet and is carried into the furnace in a highly divided state. The amount of steam required is about equal, by weight, to that of the tar consumed.

Axers neue selbststätige und von Hand benutzbare Schur- und Abschlack vorrichtung, Pradel. *Zeits. für Dampfkessel und Maschinenbetrieb*, March 1, 1912. 1 p., 3 figs. *d.* Description of an *automatic stoker with an automatic grate-cleaning device* invented by E. Axer, of Altona, Germany. The grate bars are laid not longitudinally, as usual, but crosswise, and may be inclined either toward the front or the back. Before reaching the fuel, the air has to pass through two sets of bars, and is therefore better preheated than in the ordinary flat grate. Half of the grate bars is stationary while the other half has a slow motion first one way and then another. This motion is adjustable, and helps better combustion and cooling of the bars, as well as breaking up of clinkers. In fact, the constant motion of the bars leaves no time for the clinkers to form and does not permit them to melt together into large lumps.

Heating

Note sur le chauffage à l'aide de la vapeur de décharge des machines monocylindriques ou de la vapeur prise au receiver des machines compound, Lecuir. *Revue de mécanique*, February 29, 1912. 8 pp., 9 figs. *c.*

Comparison of various *systems of steam heating* in connection with steam power plants from an economic point of view.

There may be two cases in accordance with the pressure used in the heating mains, which may be either that of the boiler, or less. In the first case the best plan is to have the steam engines consume as little steam as possible, and to return to the boiler the water of condensation from the heating system by a steam loop: a hot water pump is to be avoided owing to its poor efficiency. If the pressure in the heating mains is less than that in the boiler, one of the following three systems may be used: (*a*) the steam may be taken from the boiler, and the temperature of the steam reduced by a reducer; the work of expansion is, however, lost in

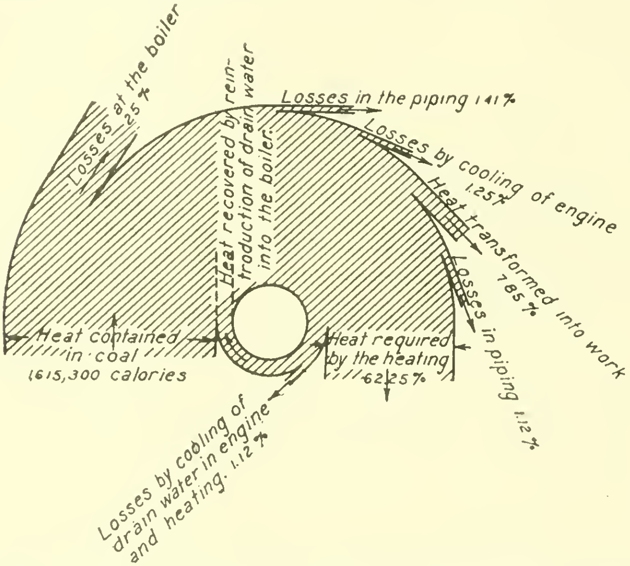


FIG. 4 HEAT BALANCE OF A SINGLE-CYLINDER STEAM ENGINE

this case, and cannot even be considered to be compensated for by the superheating of the steam, because the fall of pressure is not large enough, and the use of superheated steam in heating is but seldom advantageous. (*b*) Installation of a separate boiler having the pressure required for the heating system: this complicates the service in the boiler room, involves large losses in fuel, but is on the whole preferable to the first solution. (*c*) The use of steam which has done work: by such steam the author means steam taken from the exhaust of a single-cylinder engine or the receiver of a compound engine.

Fig. 4 represents the heat balance of a single-cylinder 200-h.p. engine. The heat necessary for heating in the plant is 1,006,500 calories (say 4,000,000 b.t.u.), and if it had to be produced separately, with coal having a heat value of 7000 calories per kilogram (say 12000 b.t.u. per lb.), about 240 lb. of coal per hour would have to be consumed.

Fig. 5 shows the heat balance of a tandem compound engine with heating with live steam. The total economy is considerably less satisfactory than in the case of a single-cylinder engine.

The relation between the type of heating and the machine used may be expressed as follows: If the heating plant requires steam in amount equal or slightly exceeding that furnished by the engines, at a pressure 300 to 600 grams (4.25 to 8.5 lb. per sq. in.) above atmospheric, a single-cylinder engine is advisable, because this pressure corresponds to the final pressure for a diagram showing the best economic utilization of such an engine. If at times a little more steam is required for heating, it may be taken direct from the boiler, and brought down to the required pressure by a reducer. If, however, the quantity of steam required for heating is con-

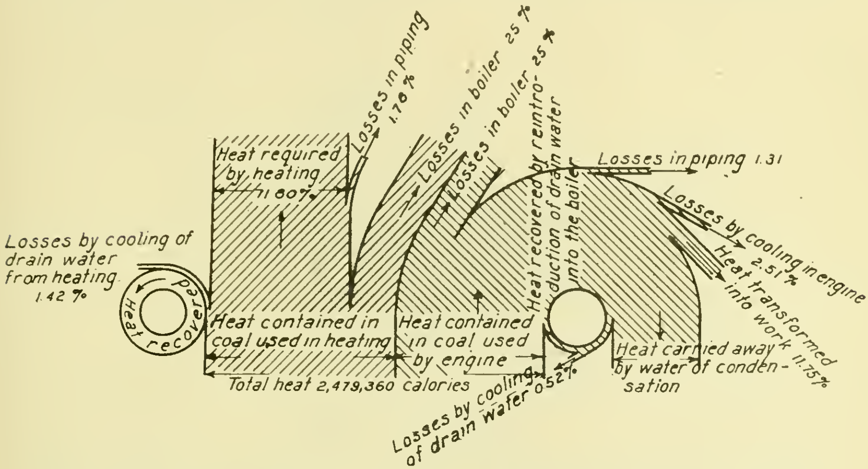


FIG. 5 HEAT BALANCE OF A TANDEM COMPOUND ENGINE WITH HEATING WITH LIVE STEAM

siderably less than that delivered by the engines, or is at a pressure of from 600 grams to 2.50 kg. (8.5 to 35.5 lb. per sq. in.) above atmospheric, a compound engine should be used, with the steam taken at the receiver and constant pressure maintained by varying the admission to the low-pressure cylinder.

This relationship exists also in the case of turbines, the high pressure turbine corresponding to a single-cylinder engine, and the two-stage turbine to a compound engine, the steam in the latter case being taken at the point where its pressure corresponds to that in the heating system.

The author shows by indicator diagrams how steam taken for heating from a compound engine affects the working of the engine. When steam going to the low-pressure cylinder is taken to the heating system, the work that would have been developed in it has to be made up by the high-pressure cylinder, and if much steam is regularly taken in order to insure normal working of the engine, the volume of the low-pressure cylinder

must be decreased. If too much steam were taken, the low-pressure cylinder would receive none, and would give no work; the engine would then work as a single-cylinder engine with back-pressure, driving the low-pressure cylinder at no-load, and its efficiency would be very poor. On the other hand, if too little steam is taken, too much load is thrown on the low-pressure cylinder. There are therefore certain upper and lower limits of admission to the low-pressure cylinder, which must be maintained by some sort of regulation either by hand or automatically, in order that the plant should work at its maximum efficiency. In general the tandem or cross-compound engine lends itself better to the taking of steam from the receiver than a twin-compound engine.

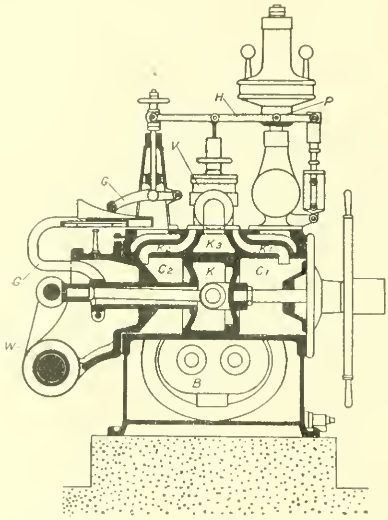


Fig. 6 Oil Regulator in the Bell Water Turbine

Hydraulics

Le turbine idrauliche. *L'Industria*, March 17, 1912. 1 p., 3 figs. *d.* Description of the *hydraulic turbines* of the Société anonyme des Ateliers de Construction de Th. Bell et Cie de Kriens (Lucerne, Switzerland). The turbine is of the Francis type. The *regulator* is shown in Fig. 6. The oil under pressure is driven from the reservoir B by a pump, driven by the pulley S, to the valve gear V, which communicates with the cylinder chambers C_1 and C_2 by the ducts K_1 and K_2, and with the reservoir B by the duct K_3. The valve gear is regulated by the spring governor R in such a way that the pressure acting on one side of the piston K varies according to the conditions of work of the turbine, and produces displacements of the piston which are transmitted to the governor spindle. To decrease the stroke of the piston, and to prevent excessive opening and closing of the turbine, the gear rod G is provided to bring the valve into its middle

position, so that when the number of revolutions of the turbine is constant, the pump works as if there were no pressure, and it had only to make the oil circulate, thus making the consumption of power very slight.

Internal-Combustion Engines

Perfectionnement des moteurs à combustion interne par le réchauffage préalable de l'air, A. Nougier. *Le Génie Civil*, March 2, 1912. 3½ pp., 3 figs. *dt.* Continuation of the article abstracted in *The Journal* for April (p. 615) on the *improvement of internal-combustion engines by preheating of the air* admitted to the cylinders.

The author recommends a preheater constructed on the principle shown in Fig. 7. It is built like a semi-tubular boiler, the hot exhaust gases passing through the flues in one direction, and the air traveling in the opposite direction, the baffle-plates MN forcing the air to take the longer path indicated by the arrow line.

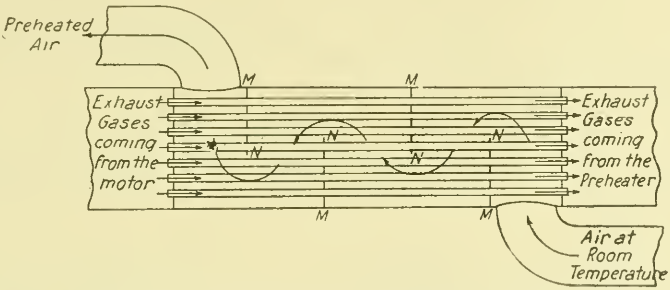


Fig. 7 Nougier Air Preheater for Internal-Combustion Engines

The difficulty in the application of this method lies in the fact that, with a 200-h.p. motor taking in the air at room temperature, the temperature of the exhaust at full load is 466 deg. cent. (870 deg. fahr.), but only 135 deg. cent. (275 deg. fahr.) at no load, and this temperature is too low sufficiently to preheat the air, or, if the preheater were made efficient at this temperature, it would preheat too much at full load, and too high preheating, as was shown in the preceding article, is not economical. By a detailed calculation the author proves that a preheater can be constructed which will preheat the air to 80 deg. cent. (176 deg. fahr.) at no load, and will not overheat the air at full load; this preheater will be only 0.60 m (23 in.) in diameter, and will contain 100 tubes, 21/15 mm (0.055 in.) in diameter and 1.06 m (39.6 in.) long.

The author proceeds to calculate in detail the thermal efficiency of the motor with 35 atmospheres compression with and without preheating, and with 25 atmospheres compression with preheating, and shows that when the compression remains the same, the thermal efficiency of the motor is not affected by preheating, and that the thermal efficiency of the motor with 25 atmospheres compression and preheating is only about 4 per cent less than that of the motor at 35 atmospheres compression without pre-

heating. Since, however, the reduction of compression pressure will give considerable mechanical advantages, very probably exceeding 4 per cent, there appears theoretically to be good ground to believe that preheating of the air will give an over-all increase of efficiency.

Über eine neue Bauart des Kerpely-Gaserzeugers, H. Hermanns. *Dinglers Polytechnisches Journal*, March 9, 1912. 2 pp., 1 fig. *d*. Description and data of tests of a new type of the *Kerpely gas producer* using cheap fuel, and utilizing waste heat for the production of steam. *Cp. The Mechanical Engineer*, March 29, 1912, and *Stahl und Eisen*, December 28, 1911.

Neuere Rohölmotoren. Ch. Pöhlmann. *Dinglers Polytechnisches Journal*, March 30, 1912. 4 pp., 19 figs. *d*. Extensively illustrated description of the Breslau oil motor, with many details on the construction of its cylinder cover and compressor.

Neuere Rohölmotoren, Ch. Pöhlmann. *Dinglers Polytechnisches Journal*, March 16, 1912. 2½ pp., 4 figs. *d*. Description of *high-speed oil motors* built by the Augsburg-Nuremberg Co. and by the Breslauer A. G. für Eisenbahnwagenbau und Maschinenbauanstalt. The latter motor gives 450 effective h.p. at 400 r.p.m.

Motori à combustione interna. *L'Industria*, March 17, 1912. 2 pp., 9 figs. *d*. Description of the Henriod, Cottereau, Broc, and Ballot *slide valve motors* (Cp. *The Journal*, March, 1912, p. 414, and the *Automobile*, August 3. 1911).

Machine Shop

Procédé de fabrication des tubes en U. *La Métallurgie*, March 20, 1912. 2/3 p., 12 figs. *d*. Description of a *process for making U-tubes*, in particular for superheaters, patented in France by W. Schmidt. This process requires no special tools, and is claimed to produce a tube of great homogeneity at the joint. A rather deep groove, 3, as shown in Fig. 8, is cut in the tube, normal to its longitudinal axis, so as to obtain at the place where the U is to be formed two tubes connected by a short strip *c*. The tubes are then bent back about an axis passing through the strip *c*, into the position shown in 4, the distance between the axes of the tubes depending on the width of the groove. Next a piece of flattened tube *e* (9 and 10) is placed on the mandrel *d*, hammered into shape, and the joint above the mandrel welded, so that a sort of cap *f*, open at one end, is obtained. This cap is hammered or pressed over a mandrel into the shape shown in 7 and 8, placed over the tubes *a* and *b*, and welded (1 and 2). The presence of the connecting strip *c* is said to offer the following advantages; no weld is necessary at the narrowest place, i.e. just between the tubes; only two pieces have to be handled in welding; the presence of the strip makes the joint stronger.

Benzol-Schweissung. *Autogene Metallbearbeitung, Beiblatt zu Acetylen*, February 15, 1912. 5 pp., 1 fig. *cd*. Description of *oxy-benzine welding*, and comparison of it with oxy-acetylen welding. The temperature produced by the oxy-benzine flame is about 2800 deg. cent. (5072 deg. fahr.) against 3200 deg. cent. (5792 deg. fahr.) of the oxy-acetylen flame. The

time required for welding with oxy-benzine is longer, from 30 to 100 per cent., in accordance with the thickness of the material. Plates of more than 8 mm. (0.31 in.) cannot be safely welded by oxy-benzine, because benzine is not a chemically pure product, and contains hydrogen which dissolves in iron at the temperature of welding, but separates at cooling, forces its way outwards from the joint, and in doing so makes a path for the escape of carbon; the joint is therefore apt to lose its carbon, and to become hard and brittle. A further disadvantage of the oxy-benzine method

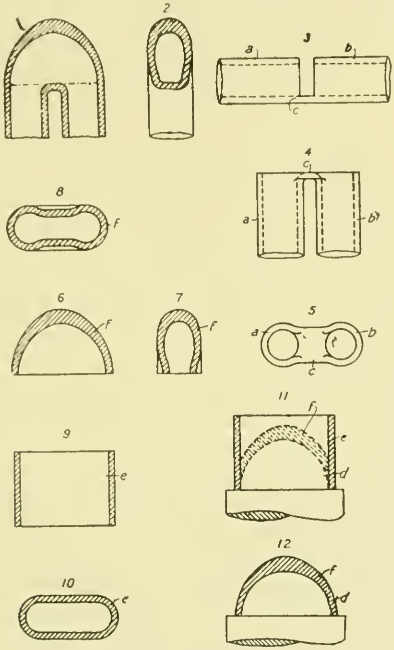


Fig. 8 Process for Making U-Tubes

of welding consists in the fact that, as has been shown experimentally, the quality of work is substantially affected by the temperature and conditions of work in the place where the welding is carried on; at low temperatures (below 4.5 deg. cent., or 40.1 deg. fahr.) the benzine freezes, and must be either heated or mixed with alcohol, the latter unfavorably affecting the strength of the joint produced; drafts of air are liable to change the proportion of benzine and air mixture in the carburetor spiral, and that in its turn affects the quality of the work done. Benzine fumes are to a certain extent dangerous to the health of the workmen, although the products of its combustion are harmless. The use of oxy-benzine welding for regular shop or factory work cannot therefore be recommended, but the compactness of the apparatus and practical safety from explosions make it very convenient for road and erecting work. Fig. 9 shows the comparative cost

of oxy-benzine and oxy-acetylen welding per meter (or 39.37 in.) of welded seam in pfennigs, the plates welded being in millimeters (1 mm equal to 0.039 in.), and the basis of comparison being: acetylen at 1 M. per cu. m., or, say, 0.71 cents per cu. ft.; benzine, 90 per cent pure, 24 pfennigs per kilogram, or, say, 2.7 cents per lb.; oxygen and labor in both cases, the first 1 M. per cu. m., or 0.71 cents per cu. ft., and the second 60 pfennigs, or 15 cents, per hour.

Procédé et appareils pour la fabrication des plaques métalliques. *La Métallurgie*, March 13, 1912. 1 p., 3 figs. *d.* Description of a new *process for galvanizing metallic objects*, invented by Kar Miehl of Gutersloh, Germany. The objects to be galvanized are placed on a special receptacle provided with holes like a screen, and are dipped into a bath of galvanizing metal, and kept there until they attain a temperature very

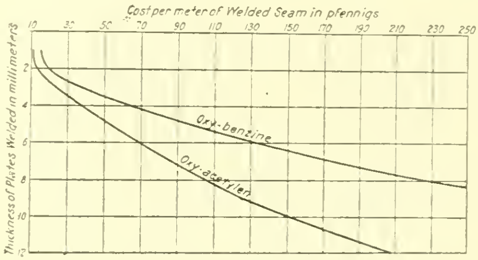


Fig. 9 Comparative Cost of Oxy-Benzine and Oxy-Acetylen Welding

near that of the bath. The receptacle with the objects on it is then quickly transferred to a drum which is set into rapid rotation. Owing to the action of centrifugal force, in a fraction of a minute all the excessive fluid material is projected outside of the receptacle, and the objects remain covered by a uniform and closely adhering layer of metal. This process permits of galvanizing very small objects, e.g. needles, as well as such objects as screws, which could not be galvanized by simple immersion in hot metal because the metal would fill the screw thread. The article also describes the simple machinery used in this process.

Mechanics

Note sur le calcul du travail du métal dans les cables métalliques, Edgar Baticle. *Annales des Ponts et Chaussées*, January-February, 1912. 20 pp., 9 figs. *mtA.* Mathematical investigation of the causes producing rapid *deterioration of wire ropes*. The author gives formulae for determining the stresses in the rope when its radius of curvature is known, and shows how to determine, in load ropes, the sum of the components of bending moments and moments of torsion. He concludes that it is possible by the usual methods of determining the resistance of materials to find the total stress in the most stressed fibers of a rope, whether wound about a drum of known radius, or subjected to a concentrated load which gives it a certain curvature of unknown radius. This total stress is composed of the stress of tension, bending and torsion stresses, the last being smaller in a

well made rope. The bending stress in the wires composing the rope is due to the following two causes: (*a*) in the manufacture of the rope the wires are often subjected to considerable stresses resulting in their losing some of their power of resistance; (*b*) the influence of the bending of the rope under a live load, or while coiled on a drum. The stress due to the last cause is variable. If, as we believe generally happens, the total stress exceeds the limit of elasticity, the variable and repeated stress due to bending must rapidly cause plastic deformation in the metal. The stress produced in manufacturing the rope varies inversely as the radius of "elementary wire." The same is true for the bending stress in a rope coiled on a drum of a definite diameter, but in load ropes the stress is independent of the diameter of the elementary wire.

From the method applied by the author it follows that, as regards deformation, a rope may be considered as a member under flexure, provided an imaginary moment of inertia is attributed to it, of which the author gives the value as a function of the total section of the rope, radius of the elementary wire, and angles of coiling of the wires and strands. The flexibility of a rope is measured by the reciprocal of this imaginary moment of inertia, and is inversely proportional to the radius of the elementary wire and radius of the rope, but varies with the method of making the rope, and is generally greater in a rope of several strands than in a rope made of a single strand.

THEORETISCHE BERECHNUNG EINER SCHLEUDERPUMPE AUF GRUND VON VERSUCHEN. H. C. A. Ludwig. *Die Turbine*, Nos. 1 to 12, 1911 to 1912. *t*. The author shows from a test of a *centrifugal pump* how the data obtained experimentally may be brought into agreement with theoretical values. He draws the usual *O-H* curves from an empirical formula, and proves that these curves agree with the values for impacts of water obtained in accordance with the usual theory. He further compares his *O-H* curve with those of other investigators, and shows their material agreement.

ÉTUDE GRAPHIQUE DE LA RÉSISTANCE DES PIÈCES À FORTE COURBURE RELATIVE, F. Legein. *Bulletin technique de l'Association des ingénieurs sortis de l'École polytecnique de Bruxelles*, February, 1912. 17 pp., 6 figs. *mA*. Prof. W. Ritter (*Der elastische Bogen*) has graphically studied the *resistance of arches* of small curvature. The author applies his method to the case of members *of large curvature*, and, by way of example, shows how to apply it to the investigation of a ring, of circular section, and radius of curvature equal to $2r$, acted upon by an axially directed force.

VERSUCHE ÜBER DIE STRÖMUNGSVORGÄNGE IN ERWEITERTEN UND VERENGTEN KANÄLEN. H. Hochschild. *Mitteilungen über Forschungsarbeiten auf dem Gebiete des Ingenieurwesens*, Vol. 114, 1912. 53 pp., 70 figs. and 27 tables. *e*. Account of an investigation of the *conditions under which flow takes place in expanded and contracted passages*, such as are met with in turbines and turbo-blowers. The theory of Prof. L. Prandl was laid as a basis of investigation, and the author quotes from his manuscript as follows: if two particles of a fluid glide over one another in such a manner that in a distance dy there is a difference of velocity dw, there is produced in the surfaces of gliding contact a shearing stress $t = k\,\frac{dw}{dy}$ The con-

stant k is called the coefficient of internal friction, or viscosity. The author's experiments have throughout corroborated this theory. Measurements of hydraulic pressure have shown that in contracted passages the flow occurs with nearly no losses (potential flow), and as the passage expands, the conditions of flow become less favorable. Further investigations by means of a special little tube (arranged somewhat like a pitot tube) have shown that the losses, in the form of eddies formed by friction, arise mainly at the walls of the passage, and gradually permeate the whole stream ("*Turbulenz*," whirls), and that in direct proportion to the expansion of the passage and rate of decrease of velocity and increase of pressure.

Versuche mit Riemen besonderer Art, Kammerer. *Zeits. des Vereines deutscher Ingenieure*, February 10, 1912. 7 pp., 15 figs. *eA.* Account of tests on the *limits of effective stress in belts* of various materials. Such tests require a large expenditure of time because overloading of a belt can be discovered only from the appearance of a permanent elongation, and an identical elongation is also found in a new belt which has not yet reached its state of resistance. Since, however, several hours are required for a belt to reach that state, there is always a danger in short tests with new belts of taking phenomena of the state of resistance for those of overload.

Tests of Link Belts. The tests were made on two link belts of equal width, but unequal thickness, made up of links pressed out of specially prepared fiber, and provided with leather rims. The tests have shown that at a speed of 15 m (say 50 ft.) per sec., the total stress on the tight side of the belt must not exceed 30 kg per cm (166 ft. per in.) of width of belt, but at higher speeds may go as high as 35 kg per cm (193 lb. per in.) of width of belt. Link belts have been introduced because they combined the strength of double with the flexibility of single belts, and gave strong belts which could be used on pulleys of small diameter. These tests have shown that for speeds up to 20 m (65 ft.) per sec. link belts are far superior not only to single, but even to double, leather belts, but at higher speeds the centrifugal tension in the heavy link belt decreases the allowable useful load very materially, and at speeds over 30 m (98 ft.) per sec. link belts cannot be economically used at all.

Tests of Leather Belts. For speeds up to 15 m (50 ft.) per sec. the total stress in the tight side of the belt did not exceed 23 kg per cm (say 126 lb. per in.) of the width of the belt, while for speed of 30 m (98 ft.) per sec. the total useful tension rose to 26 kg per cm (143 lb. per in) of width of belt.

Americans often assert that belts which are turned with the *hair side to the pulley* last longer than when turned with the flesh side to the pulley, as is usual in Germany. Tests made by the author have shown that in belts turned with the hair side to the pulley: (*a*) the tension ratio, or ratio between the tension on the tight side and that on the loose side hardly exceeds 2, while in belts running with the flesh side to the pulley it can exceed 3; (*b*) the highest allowable tension is more than 3 kg per cm (12.6 lb. per in.) less than in the case of belts with the flesh side toward the pulley; the speed cannot be made more than 30 m (98 ft.)

per sec., against 50 m (164 ft.) with belts with the flesh side toward the pulley. This shows that it is in every respect disadvantageous to let the belt run with the hair side toward the pulley. A belt running in that way probably wears out sooner because, as was pointed out by C. O. Gehrkens, such curvature reverses the way in which the hide grew on the animal.

Tests of High-Speed Belting. A double cemented leather belt, 45 mm (1.8 in.) wide, stood very well a total tension on the tight side of 67.1 kg per cm (370 lb. per in.), at 60 m (196 ft.) per sec., and broke only when the tension rose to 95.9 kg per cm (say 530 lb. per in.). The allowable useful stress k_n can be deduced from the formula

$$k_n = (k_T - k_f) \times {}^3/_4$$

where k_T is the total stress on the tight side, and k_f the centrifugal tension.

Tests on Belt Fastenings. In the tests with woven belts it was found that, as the speed of the belt transmission increased, the allowable useful stress diminished owing to the influence of the belt fastening, which at speeds from 25 to 30 m (81 to 98 ft.) per sec. caused such vibrations and uncertainty of run that it proved to be impossible to exceed the speed of 30 m (98 ft.) per sec. The influence of the fastening is due to the following causes: (*a*) through the center of gravity of the fastening describing on the pulley a semicircle, an additional centrifugal tension is developed equal to

$$k'_f = \frac{G}{bl}\,\frac{v^2}{g}$$

this additional centrifugal tension is thus a function of $\frac{G}{bl}$, or weight of unit area of the fastening, and that indicates the advisability of arranging the fastening in such a way that its weight be distributed over as large an area of the belt as possible; (*b*) the rotation of the fastening in coming on and off the pulley produces in it a moment of torsion which in its turn produces in the belt an additional centrifugal tension. This tension becomes negligible if the fastening is made of flexible steel bands, softer steel bands lasting longer than hard ones.

The article also contains data on tests of woven belts, and discussions on the theory of belting which could not be reported owing to lack of space.

Refrigeration

Die Verbesserung der Kohlensäure-Kältemaschine durch Einführung eines Expansionzylinders, R. Plank. *Zeits. für die gesamte Kälte-Industrie*, March 1912. 3 pp. *t.* Discussion of the improved *carbon dioxide refrigerating machine* with a separate expansion cylinder proposed by L. Horst (see *The Journal*, February, 1912, p. 294). Plank finds that the machine is based on correct thermodynamic principles, and represents a real improvement on the present CO_2 refrigerating machines, but not as large an improvement as Horst claimed.

Steam Engineering

Zur Streitfrage der Gleichstrom-Dampfmaschine, E. Tuckermann. *Dinglers polytechnisches Journal*, March 9, 1912. 4 pp., *ct.* Comparison

of the *straight-flow steam engine*, as designed by Stumpf, with other similar types, and discussion of its mechanical characteristics. The peculiar property of the straight-flow steam engine is that, as a single-cylinder engine, it works with saturated steam just as economically as with superheated, and in heat economy reaches a degree as high as, or higher than, large multi-cylinder engines with superheat. That does not mean that superheating the steam is of no value whatever. On the contrary, all along the way up to the admission valve the economy of superheat even in straight-flow steam engines cannot be denied, but, once inside the cylinder, dry saturated steam gives as good results economically as superheated, because it does not require as expensive a lubrication system as an engine for superheated steam. The working cycle of the straight-flow steam engine approaches more the Carnot cycle than does that of an engine working with superheated steam, the admission line in the first case being more of the nature of an isotherm, and for the latter of an isobar, of the gas. For equal heat losses during the admission periods in both engines, the pressure in the superheat engine falls more rapidly than in the saturated steam engine. The value of superheating lies in the fact that it compensates for losses causing the performance of the engine to depart from that of the ideal engine, and if these deviations are overcome in some other way, superheating becomes superfluous.

There is a substantial difference between a straight-flow and alternating-flow steam engine in the working of the exhaust. Suppose that in both cases the steam at the end of expansion is wet. In a straight-flow engine it becomes immediately dry, because it suddenly expands without doing any work, and thus preserves its heat, while the pressure goes down. The piston head is therefore dry at the beginning of compression, and the heat flowing from the walls and especially from the hot cylinder cover, highly superheats a large amount of steam. In an alternating-flow steam engine the exhaust lead is not as rapid, and the piston drives part of the wet steam toward the exhaust, and owing to the high velocity of the steam flow, cools both the admission and exhaust openings: the exhaust may be said to come out cold. The piston, which is wet, remains all the time in contact with the cold exhaust steam, and more heat is required for evaporation than in the case of a straight-flow engine. The average difference of temperature between the walls and exhaust steam, and consequently the heat given off to the exhaust steam, is greater in the case of an alternating-flow engine, but all that heat goes into exhaust, and is not utilized as in the straight-flow engine.

The valve gear of the straight-flow steam engine is remarkably simple, owing to the absence of the exhaust gear. The exhaust area is made as large as practicable, an ideal equilization of pressures between the cylinder and condenser being simply a result of the constructive peculiarities of the engine.

The use of a long piston is generally pointed out as one of the disadvantages of the straight-flow engine. The author argues that long pistons have been used quite successfully in gas-engine construction, and that it ought to be all the more easier to use them in steam engines, especially such as do not make use of high superheats.

Abwärmeverwertung an Siemens-Martin-Ofen zur Dampferzeugung, A. Pfoser. *Stahl und Eisen*, March 7, 1912. 1 p., *p*. Discussion of the *utilization of heat of gases discharged from a Siemens-Martin furnace*. The temperature of the gases is 600 to 700 deg. cent. (1112 to 1292 deg. fahr.), and the heat losses are therefore very large. The plant investigated by E. Mayer (Die Wärmetechnik des Siemens-Martin-Ofens) has, in round figures, the following heat balance:

	Per Cent
Total useful work	27.0
Losses by radiation of the furnace and regenerators	29.0
Losses by exhaust	31.0
Combustible in the ash-pan of the gas producer	3.0
Losses by radiation of the gas producer	10.0
Heat produced by the combustion of coal	100.0

The author shows that by using the discharged gases to produce steam at 10 atmospheres pressure above atmospheric, which can be done by reducing the temperature of the exhaust gases to 300 deg. cent. (572 deg. fahr.), the efficiency of the furnace can be improved 16.7 per cent. The important problem is, however, to have the steam-producing plant designed in such a way as not to interfere with the work of the Siemens-Martin furnace, which after all is the most important part. To do this, the smokestack must be large enough to give a sufficient partial vacuum to overcome the increased friction due to the lengthening of the path of the gases. When artificial draft is used, an economizer may be installed behind the boiler, the temperature of the escaping gases reduced 150 to 200 deg. cent. (302 to 392 deg. fahr.), and about 20 per cent more steam produced. The author claims to have constructed successfully working installations of this kind in connection with zinc and glass melting furnaces.

Les avaries des plaques tubulaires dans les chaudières de locomotives, H. Lavialle d'Anglards. *Le Génie Civil*, March 9, 16, 1912. 4 pp., 10 figs. *p*. Investigation of causes of *breakdowns in tube plates of locomotive boilers*, and description of methods of repair, both on the road and in the shops. If the plate broke between two or three flues, and there is no time to send the locomotive to the shops, the flues are removed, and the hole covered by a buffer plate; the plate is generally placed on the inside of the boiler, with the screws on the furnace side. If more than two or three flues are affected, putting them out of business might cause serious inconvenience, and therefore the solid buffer plate is not used then; instead, the diameter of the end of the flue is reduced, a ring (steel, bronze, or red copper) screwed into the slot so as to cover the broken part of the plate, and the flue hammered over the ring.

The tube plates break down particularly often on locomotives working on lines of uneven profile. When going up a grade, the exhaust is strong, the fire active, the flue tubes get hot and tend to expand, which they can do only toward the inside of the boiler owing to the rigidity of the tube plate; as a result, the plate is under strain. When the train goes down grade, the temperature of the tubes rapidly falls, especially if the injector is set into action, they suddenly contract, and exert a powerful strain on the plate in an opposite direction. These rapid changes of

stresses acting on hot metal produce in it fatigues, and finally lead to breakdowns.

To preserve the plates the author recommends: preheating of feed water (tried on two series of locomotives, but too recently to have any results recorded); superheating (in trials on a large French system it was found that the locomotives without superheat had their tube plates all cracked after a run of 150,000 kilometres (say 93,000 miles), while the plates in locomotives with superheat were intact); choice of suitable materials (on the Saxony railroads good results were obtained with the upper part of the tube plate made of steel, while the lower was of copper, to better resist the action of the fire).

La turbina à vapore "Tossi" marina, Fr. Modugno. *Rivista Marittima*, February 1912. Description of the *Tossi marine turbine*. (Cp. *The Engineer*, London, July 22, 1910).

Die Anfangstemperatur als eine wertvolle Kontrolle bei Verdampfungsversuchen, O. Binder. *Chemiker-Zeitung*, March 14, 1912. 2 p. *t*. Discussion of *initial temperature as a valuable method of control in evaporation tests*. The total heat evolved during combustion is at the moment of combustion contained in the gases of combustion. Therefore, if the initial or combustion temperature, the volume of gases of combustion, and their specific heat is known, it is easy to calculate the heat of combustion, and this must be equal on one hand to the sum of the heat in the steam, the heat in the exhaust gases, and heat losses by conduction and radiation, and on the other hand to the theoretical heating value of the fuel, minus the latent heat in the residues of combustion and unconsumed gases and soot. The losses by conduction and radiation may be determined by heating the boiler plant up to a certain steam pressure, removing the fire, and closing the fire doors and dampers air tight. The losses by conduction and radiation can then be determined from the fall in steam pressure after some little time.

The author has shown elsewhere (*Mitteil. über Gegenstande des Artillerie-und Geniewesens* 1911, vol. 2) that the initial temperature may be found from the following formula:

$$T = \frac{\text{Cal.} - w}{CO_2(0.4886 + 0.00024\,T) + N(0.308 + 0.00007\,T) + H_2O(0.4692 + 0.00015T)}$$

where *Cal.* is the theoretical heating value of the fuel, w the undeveloped heat; CO_2 volume of carbon dioxide evolved from 1 kg. of fuel; N volume of nitrogen, oxygen, and other gases, having the same specific heat, evolved from 1 kg. of fuel; H_2O volume of steam corresponding to 1 kg. of fuel.

The heat required to raise the temperature of the gases of combustion by 1 deg. cent. is a function of their volume and specific heat. The general formula for initial temperature is $\frac{\text{WE}}{\text{v}.\sigma}$, where WE is the total heat developed in WE (1 WE is equal to 3.97 b.t.u.), v volume of gas, and σ its specific heat. The total heat developed can be found from the theoretical heating value of the fuel, by subtracting from it the latent heat in the residues of combustion, soot, and unburned gases. The volume of the gas can be computed from the contents of carbon dioxide in the gas, and the analysis of the fuel, in the usual way. Thus,

from the data of a test, in 1 cu. m. of gases of combustion there is $0.5364 \times 0.097 = 0.05203$ kg. of carbon (1 cu. m. of carbon dioxide contains 0.5364 kg. of carbon). But 1 kg. of coal contains 0.6337 kg. of carbon, and therefore from 1 kg. of coal $\frac{0.6337}{0.05203}$, or 12 cu. m. of gases of combustion are evolved. The total heat evolved can therefore be expressed by the following quadratic equation:

$$T \times CO_2 \times 0.4886 + 0.00024T^2 + T \times N \times 0.308 + 0.00007T^2 \times N + H_2O \times T \times 0.4692 + H_2O \times T^2 \times 0.00015 = WE$$

or, more generally:

$$T.a + T^2.b = WE; \qquad T^2 + \frac{a}{b}T - \frac{WE}{b} = 0$$

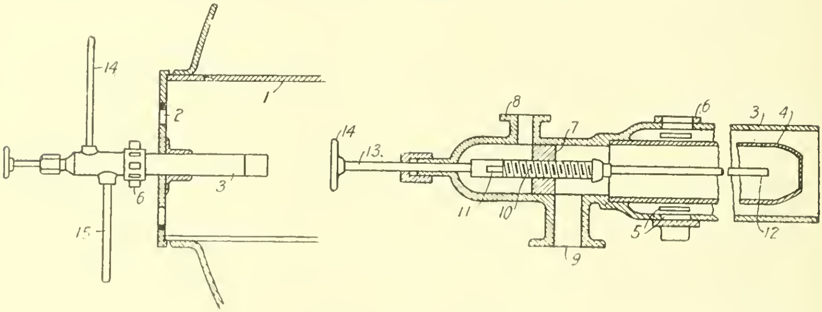
The author proceeds to apply his formula by calculating the data from four tests, and shows that the values obtained by his method are very close to the theoretical heating values.

Verfahren zur Erhöhung des Nutzeffektes von Feuerungsanlagen. *Zeits. des internationalen Vereines der Bohringenieure und Bohrtechniker*, March 15, 1912. 2 pp., 8 figs. *d.* Description of the process invented by Max von Eberhardt for *improving the efficiency of furnaces.* The inventor started from the well-known fact that when combustion is proceeding with air as the supply of oxygen, nearly four-fifths of that air consists of nitrogen which does not help combustion, but takes up a large amount of heat which otherwise might do some useful work. The *inventor therefore brings oxygen to the fuel in the form of superheated steam,* i.e. in connection with hydrogen, the advantage being that, after the steam has dissociated into its component parts, the hydrogen unites with some of the carbon and forms hydrocarbons which materially increase the thermal result of combustion. In fact, the author claims that so high a temperature is obtained that air, and consequently nitrogen, have to be introduced into the furnace as a cooling medium, to make the process practicable for ordinary boiler-plant work. The article describes how this method can be adapted to flue boilers, and oil and gas-fired furnaces. Only the first is abstracted in this article.

The apparatus for use with flue boilers (Figs. 10 and 11) is set as shown in Fig. 10, 1 being the flue, and 2 the flue wall. It consists (Fig. 11) of a casing 3, open at one end, containing a tube 4 somewhat contracted in its forward end. All around the casing there are slots 5 which can be more or less opened or closed by the slots on the ring 6 set on the outside of the casing. The inside of the casing 1 is divided by the bearing 7 into two chambers respectively connected with the junction-pieces 8 and 9. In the bearing 7 is located a hollow threaded spindle provided with slots 11, and carrying at one end a pipe 12 open in front, and at the other end a solid spindle 13; this spindle passes through a stuffing box in the wall of the casing, and is provided with the hand-wheel 14. (Fig. 10). The steam is conducted to opening 8 through the pipe 14 (Fig. 11), the gas to opening 9 through the pipe 15, while the admission of air is regulated by the position of the ring 6. The temperature of the flame is regulated to a certain extent by the mutual position of the ends of the pipes 12 and 4, since the rate of diffusion of the steam, and therefore the amount of hydrogen

brought into the flame is inversely proportional to the distance between the ends of the two pipes. The author does not explain how he succeeds in effecting the dissociation of steam into its component parts, but states that tests made with gas and oil furnaces "have shown the correctness of the theoretical calculations."

Die 41. Delegierten- und Ingenieur-Versammlung des Internationalen Verbandes der Dampfkessel-Uberwachungs-Vereine. *Glüekauf*, March 23, 1912. 8 pp. *g*. Report of the 41st meeting of the delegates of the International Association of Boiler Inspection Societies. Among other things was discussed the best material for *stop-valves for superheated steam*. The expectations entertained as late as 1906 that the cast-iron valve would be very soon forced out of business did not materialize. It is cheaper, and that is an important consideration at a time when boiler



Figs. 10 and 11 Eberhardt Apparatus for Firing with Steam as Source of Oxygen

manufacturers justly complain of reduced profits. In small valves, i.e. valves with walls not thicker than 10 mm (0.37 in.), cast iron proved to be even preferable to steel, because thin steel castings, unless made of nickel steel or other suitable alloys are not reliable. Valves of section of opening of 150 mm (5.7 in.) or over, ought to be made exclusively of steel. The report contains a detailed discussion of the heating of stop-valves, and standard rules for their construction.

Das Interferometer zur Untersuchung der Dampfkesselrauchgase, H. L. *Braunkohle*, March 22, 1912. 7 pp., 9 figs. *d*. Description of new apparatus of Carl Zeiss in Jena, Germany, for *optical analysis of gases of combustion* by means of an interferometer. The analysis is based on the fact that the refractive power of the gases of combustion depends on the contents of CO_2, and therefore a gas refractometer could be constructed permitting the reading of the analysis of a gas from a scale by simple inspection. The article describes several types of apparatus: a simple, portable, apparatus for boiler-room use, exact to within 0.1 to 0.2 of 1 per cent, and a more complicated one for laboratory use, exact to within 0.01 of 1 per cent. From the description the handling of the apparatus appears to be comparatively simple.

Strength of Materials and Materials of Construction

Eisenportlandzement im Vergleich zu Portlandzement, H. Passow. *Stahl und Eisen*, March 21, 1912. 3½ pp. *c.* In 1909 the Prussian Ministry of Public Works admitted *slag cement for use in public works* equally with portland cement. This was done after exhaustive tests at the Royal Laboratory at Gross-Lichterfelde West which showed the equality of both kinds of cement as far as strength and other qualities were concerned, the only point on which slag cement was in some instances found to be inferior to portland cement being in its resistance to the action of the atmosphere, but even that only to a very small degree. The commission in charge of these tests made arrangements for 5 and 10-years' tests, the first of which have just been finished. The article gives extensive abstracts from the reports of the commission in charge of the tests (the complete report will not be published for some time), the final conclusion being that, as materials of construction, slag cement and portland cement are of equal quality.

Versuche mit umschnürtem Gusseisen. System Dr. v. Emperger. *Beton und Eisen*, March 11, 1912. 3 pp., 20 figs. *de.* Continuation of the article on "*strapped*" *cast iron*, i.e. cast iron surrounded by a concrete jacket, in its turn reinforced by an outer helically wound steel wire. The axial distance between the turns of the wire must be at least equal to the thickness of the concrete core, and higher compression strength can be obtained when the wire is wound still closer.

Versuche über die Verdrehung von Stäben mit rechteckigem Querschnitt und zur Ermittelung der Längs- und Querdehnung auf Zug beanspruchter Stäbe, O. Bretschneider. *Zeits. des Vereines deutscher Ingenieure*, February 17, 1912. 6 pp., 10 figs. *e.* Account of experiments on torsion in bars with rectangular cross-section, and their elongation and reduction of area under tension. It was found that in low carbon steel bars with the ratio of sides from $h:b = 1:1$ to $h:b = 10:1$, the angle of torsion within the limit of elasticity, can be found from the formula

$$\theta = \psi^1 M_d \beta \frac{b^2+h^2}{b^3h^3}$$

where for ψ_1 must be substituted the values calculated for different ratios of sides by Saint-Venant, and reproduced by the author in one of the tables, and M_d is the moment of torsion, β the coefficient of shear, b the shorter, and h the longer side of the rectangular cross-section of the bar. The largest difference between the values obtained from tests and those calculated from this formula does not exceed 1.5 per cent. For bars with ratio of sides of cross-section from $h:b = 1:1$ to $h:b = 6:1$ according to tests, for ψ_1 may be substituted

$$\psi^1 = 3.645 - 0.06\frac{h}{b}.$$

The article also contains a discussion of the distribution of stresses in the section of the bar, with 4.5 substituted for the values of ϕ given by Saint-Venant in the equation for maximum shearing stress, and a discussion of relation of elongation to reduction of area in bars under tension.

Prüfungsmaschine von 3000 t Druckkraft für Eisenkonstruktionsteile, Ad. Seydel. *Stahl und Eisen*, March 7, 1912. 3 pp., 1 fig. *d.* Description of a hydraulic *machine for testing the strength of materials* used in bridge construction, capable of exerting a pressure of 3000 tons on bars up to 15 m (say 49 ft.) long, and a tension of 1500 tons on bars up to 13 m (say 42 ft.) long. The machine was constructed by the German Association of Bridge and Railroad Supply Manufacturers, with financial help from the Prussian Government and other associations. The experimental work and distribution of data are in charge of a special board consisting of professors of technical schools and practical men.

Über die Messung grosser Kräfte im Materialprüfungswesen. *Dinglers Polytechnisches Journal*, March 9, 1912. 1 p. *t.* Account of a paper read, December 21, 1911, by A. Martens before the Prussian Royal Academy of Sciences on the measurement of large forces in testing of materials and calibration of testing machinery. One of the most sensitive methods appears to be that of G. Wazau: a cylindrical test piece, subjected to tension or compression, is placed in a vessel filled with a liquid, and the change of volume due to the elongation of the test piece is compensated for by immersion of a body actuated by a micrometer screw in such a way that the column of mercury in a capillary tube connected with the main vessel remains always at the same level. This apparatus allows the measurement of the power applied within 2 kg (4.4 lb.) when the load applied is 10,000 kg (22,000 lb.). It is, however, necessary in tests with this apparatus to look out very carefully for possible errors due to variations of temperature which materially affect the readings.

Überblick über die gebrauchlichsten Festigkeitsprobiermaschinen, W. Muller. *Dinglers Polytechnisches Journal*, March 2, 1912. *d.* A discussion and description of the usual *testing machines*, such as concrete testing presses, tension testing machines of Werder, Martens, Amsler, and Pohlmeyer, and special machines for hardness and torsion tests.

Le Tension-mètre, Captain Largier. *Mémoires de la Société des Ingénieurs civils de France*, December 1911. 14 pp., 8 figs. *d.* Description of an *apparatus for measuring tension in wires in active service.* Tightening of wires by turn-buckles necessitated the use of some apparatus that would show when the tension in the wire was approaching the limit of safety, especially since for wires of small diameter a very few number of turns of the tightening screw may mean an increase of thousands of pounds in tension per square inch of cross-section. The very simple apparatus of Captain Largier is based on the formula for the transversal vibrations of strings

$$NL = K_1 \sqrt{t}$$

where N is the number of vibrations per second, L the length of the vibrating string, K_1 a numerical coefficient, and t tension per unit area of cross-section of the string. The apparatus consists of a double rule carrying a resonator and two brackets, one fixed, and the other movable. To find the tension in a wire, e.g. in a stay-wire of an aeroplane, the apparatus is placed on the wire by special grips pressing it against the brackets, and the wire is struck by a piece of wood or pencil so as to make it vibrate; the

movable bracket is then adjusted so that the wire should give a certain definite tone, e.g. *la* (*A* of the American scale). A tuning fork may be used to identify the tone if necessary. Since N is known for a given tone, the formula reduces to

$$L = K_2 \sqrt{t}$$

where K_2 is a numerical coefficient. L and t stand therefore in a parabolic relation to each other, and the rule may be graduated in such a way that the tension in the wire may be read directly from the position of the movable bracket. A correction has to be made, however, in the case of wires of comparatively large diameter. The article contains a curve showing how the increase in the diameter of the wire affects the reading of the instrument.

Thermodynamics

Über die Temperaturänderung von Luft und Sauerstoff beim Strömen durch eine Drosselstelle bei 10° C und Drucken bis 150 Atmosphären, Emil Vogel. *Zeits für die gesamte Kälte-Industrie*, February 1912. 4 pp. *et.* Account of an experimental investigation of the *cooling effect produced in air and oxygen by flow through a throttling orifice*, at 10 deg. cent. (50 deg. fahr.) and pressures up to 150 atmospheres. The experiments were made with a constant difference between the high and low-pressure side of the opening of 6 kg/qcm (85.32 lb. per sq. in.), and with as good protection against heat losses as possible.

It was found, both for air and oxygen, that the cooling effect diminishes as the absolute pressure rises, and that there is for both gases a pressure limit beyond which the expansion to a lower pressure produces not cooling, but rise in temperature. By applying the law of $\frac{1}{T^2}$ for the reduction of temperature discovered by Thomson and Joule, the author obtains the following formulae:

for air

$$dt = (0.268 - 0.00086\, p) \left(\frac{273}{T}\right)^2 dp$$

for oxygen

$$dt = (0.313 - 0.00085\, p) \left(\frac{273}{T}\right)^2 dp$$

where dt is the cooling effect, dp the difference in pressure between the high and low-pressure sides of the opening, p the absolute pressure, taken as an arithmetical mean between the pressures on both sides of the opening, T the absolute temperature taken as an arithmetical mean between the temperatures on both sides of the opening.

It was found that, especially with low pressures, use of poor insulators between the high and low-pressure sides of the opening was responsible for quite misleading results. When hard rubber insulation was used, the relation between increase of temperature and decrease of cooling effect was found to be linear, while with porcelain and especially copper insulation not only the values of cooling effect appeared to be generally less,

but the cooling effect increased with pressure, reached a maximum at about 20 atmospheres, and then began to decrease. This can be explained by the discharge of heat through the walls of the throttling apparatus which, when the amount of gas flowing through the orifice is small, reaches the inner layers of the stream of gas, and consequently the thermometer, and thus apparently diminishes the cooling effect for low pressure. The author shows further that his formula agrees with the results obtained by Thomson and Joule, and Linde.

The inversion point, i.e. pressure beyond which the expansion of the gas through a throttling orifice produces rise of temperature instead of fall, at 0 deg. cent., is as follows:

	From van der Waals' equation.	From author's formula.
	In atmospheres.	
Air	320	312
Oxygen	362	370

This can be also expressed in the following way. The author's experimental formula may be expressed in the following general form:

$$dT = \frac{a - bp}{T^2}\, dp$$

If the gas is expanded from a higher pressure p_1 to a lower pressure p, the temperatures of the gas at the respective pressures being T_1 and T, the cooling will be found by an integration to be

$$\delta = T_1 - T = T_1 \sqrt{T^3 - 3(p_1 - p)a + \frac{3}{2}\,(p_1^2 - p^2)b}$$

and therefore the following conditions may be deduced: cooling of expanding gas if

$$p_1 + p < \frac{2a}{b}$$

no change in temperature if

$$p_1 + p = \frac{2a}{b}$$

rise of temperature if

$$p_1 + p_1 > \frac{2a}{b}$$

These phenomena cannot be explained by external work, and must therefore be ascribed to the action of intermolecular forces. The technical importance of the investigation lies in its relation to such as the Linde process of liquefaction of gases, where it is very important to know what pressures to use to obtain the greatest cooling effect.

Zustandgleichung der Dämpfe, Jar. Hybl. *Dinglers Polytechnisches Journal*, March 2, 9, 1912. 7 pp., 4 figs., 9 tables. *t.* Theoretical discussion of the *equation of steam and gases* ("steams"). The author denotes by the term "steams" gases which pass into liquid state at comparatively slight changes of temperature; each gas may be called steam when it is near its point of condensation, so that there is no distinct line of separation between gases and steams.

The author investigates the equations of state for superheated steam of Zeuner, Callendar, van der Waals, Tumlirz, and others, making use of data from the experiments of Mollier and Linde, and concludes that the most exact equations of state for superheated steam are those of van der Waals and Callendar, the second being more convenient for practical purposes owing to its comparative simplicity.

Besides steam, the gases most widely used technically in thermic processes are ammonia, carbon dioxide, and sulphurous acid.

For ammonia the author proposes the following variations of well-known equations for steam:

Tumlirz's

$$v=\frac{48.59\,T}{P}-0.0137$$

Callendar's

$$v=\frac{49.7\,T}{P}-0.0208\left(\frac{273}{T}\right)^{2.22}$$

van der Waals's

$$P=\frac{49.7\,T}{v-0.014}-\frac{461}{v^2}$$

and then shows that for saturated ammonia steam all equations, including those of Wobsa, give practically the same results. For superheated ammonia steam Callendar's and van der Waals's give again nearly equal values lying between those of the other equations

For carbon dioxide the author found, by comparing values obtained with various equations with the values from Amagat's tables, that all equations give values only approximately corrresponding to those of Amagat at low pressures, and give too high pressures at the critical point. The best results are obtained with Mollier's equation

$$P=\frac{19.32\,T}{v-0.0002037}-\frac{19.36\times e^{1-\frac{T}{T_k}}}{(v+0.0007719)^2}$$

where T_k is the critical temperature

$$T_k = 273 + 31.35 = 304.35 \text{ deg. cent. absolute}$$

and van der Waals's equation in the following form

$$P=\frac{19.3\,T}{v-0.00027}-\frac{21.1}{(v+0.00086)^2}$$

With superheated carbon dioxide vapor only the equations of Clausius and Mollier give values corresponding to those in the Amagat tables, while the other equations give more or less lower values. For high temperatures the equations of Clausius and Mollier give nearly equal values, the original equation of van der Waals higher, and his modified equation lower values, while the equations of Tumlirz and Callendar give considerably lower values.

For sulphurous acid the author found, on the basis of the tables of Cailletet and Mathias, the following forms of general equations of state

Tumlirz

$$v = \frac{13.51T}{P} - 0.01164$$

Callendar

$$v = \frac{13.3\ T}{P} - 0.008\left(\frac{273}{T}\right)^{-1.3}$$

van der Waals

$$P = \frac{13.3\ T}{v - 0.002} - \frac{40}{v^2}$$

For saturated vapor the Tumlirz equation gives values equal to those of the tables, while the other two equations give, for temperatures below 10 deg. cent., values slightly lower, and for temperature above 10 deg. cent., slightly higher than the values in the tables. The same is practically true for superheated vapor as well.

The article contains many tables and graphs comparing data from various tables with those obtained by the use of different formulae.

Miscellaneous

La déchéance des brevets d'inventions pour défaut d'exploitation, L. Bidault des Chaumes. *Le Génie Civil*, March 9, 1912. 1 p. *gA*. Discussion of the *French law* of April 7, 1902, providing that a *patent for an invention* becomes *void if not worked* for two consecutive years in France. unless the patentee presents a good excuse for his inactivity. The French courts were formerly inclined to treat the provision of excuse very liberally: thus poverty of the inventor, or refusal of railroad companies to adopt an invention referring especially to railroads, were considered good excuses. Another tendency seems to have appeared lately: in the case of the Thermos Co. the court declared the patent void owing to inexploitation, notwithstanding the fact that the company has proved that it applied to several French glass factories, and that none was willing to undertake the manufacture of the Thermos botttles. The court held that the Thermos Co., to preserve its patent rights, ought to have established a special factory.

Neue Müllereimaschinen, E. Redlich. *Der praktische Maschinen Konstrukteur*, March 14, 1912. 1½ pp., 3 figs. and 1 plate of drawings. *d.* Description of new flour milling machinery.

Das Motorpflugwesen vom Standpunkte der Industrie, Martiny. *Der Motorwagen*, March 20, 1912. 29 pp., 27 figs. *d.* Discussion of economic possibilities, and description of motor-driven plows, mainly those of the "Stock" and "Ihace" types. It appears that German motor-plow users have trouble because of the lack of technically skilled attendants. When, however, the author suggested at some meeting the advisability of sending some laborer to a motor-plow factory, where he could learn the construction and operation, he was told that that could not be done, "because the man won't come back," and he will not, says the author, as long as his wages are so low. The article contains also an extensive discussion of the question, in how far the use of motor plows can help the farmer to dispense with horses.

GAS POWER SECTION

PRELIMINARY REPORT OF LITERATURE COMMITTEE

(XVII)

ARTICLES IN PERIODICALS[1]

CAPACITY OF LARGE GAS ENGINES, INCREASING THE, F. E. Junge. *Power*, March 19, 1912. $4^1/_3$ pp., 4 figs., 1 table, 3 curves.

The problem of increasing the output of large gas engines by scavenging by compressed air, and the difference in output of ordinary and scavenged engines.

COMBINATION POWER AND ICE PLANT, Paul C. Percy. *Power*, March 26, 1912. 3 pp., 8 figs., 1 table. *d*.

Describes a composite plant in which both steam and gas are motive powers and the products are ice and electricity. Gives results of a ten-day gas power run with producers burning wood scrap.

DIESEL OIL ENGINE AND ITS INDUSTRIAL IMPORTANCE, THE, Rudolph Diesel. *The Engineer* (London), March 22, 29, 1912. 6 pp., 24 figs., 1 curve. *cdhpA*. (To be continued.) Also *Engineering*, March 22, 1912. 11 pp., 22 figs., 1 table, 3 curves. *cdh*.

Discussion of the general importance of the Diesel engine and the questions brought up by J. F. Schubeler in a paper before the Zurich meeting of the Institution of Mechanical Engineers. Describes the different types and cycles of operation of Diesel engines, their adaptation to different classes of service, and economy of operation.

DIESEL MOTOR DRIVEN LINER, SUCCESS OF THE FIRST LARGE, J. Rendell Wilson. *International Marine Engineering*, April, 1912. 6 pp., 8 figs.

General description of the engines and trials of S. S. Selandia of the East Asiatic Co.

FUEL IN THE GAS PRODUCER, SMALL-SIZED. *The Iron Age*, March 14, 1912. 2 pp., 2 figs., 1 table. *cd*.

Test results with the Kerply high-pressure type showing an advance in the use of low-grade fuels.

INTERNAL-COMBUSTION ENGINES FOR GERMAN FISHING BOATS, F. Romberg. *Engineering*, March 1, 1912. 3 pp., 29 figs.

Abstracts of paper before the Schiffbautechnische Gesellschaft, Berlin, November 23, 1911.

[1] Opinions expressed are those of the reviewer, not of the Society. Articles are classified as *c* comparative; *d* descriptive; *e* experimental; *h* historical; *m* mathematical; *p* practical. A rating is occasionally given by the reviewer, as *A*, *B*, *C*. The first installment was given in The Journal for May, 1910.

Lister-Bruston Automatic Electric Lighting Plant, The. *Engineering*, March 22, 1912. $1^1/_8$ pp., 4 figs. *d.*

Describes a self contained petrol engine and dynamo for lighting country houses.

Marine Internal-Combustion Engine, An Analysis of the Claims of the. *The Engineer* (London), March 15, 1912. 2 pp., 8 figs., 1 table. *pA.*

Compared with steam engines.

Oil Engine Driven Waterworks Pump. *The Engineer* (London), March 8, 1912. ½ p., 1 fig., 1 curve. *mpB.*

Test of pumps and engine.

Oil Power Yacht "Mairi," The. *Power*, April 9, 1912. 3 pp., 6 figs., 1 curve. *d.*

Describes the power plant consisting of a medium pressure reversing oil engine of the Diesel type.

Petrol-Driven Railway Car. *The Engineer* (London), March 29, 1912. 1 p., 2 figs. *dpC.*

Passenger and mail car for the Midland Great Western Railway of Ireland with 26-h.p. vertical engine, 4 in. bore, 5 in. stroke, 1000 r.p.m.

Producer Gas-Driven Cargo Vessel, Sea-Going, F. C. Coleman. *International Marine Engineering*, April, 1912. 3 pp., 1 fig.

General description of and performance of cargo boat.

Reversing Gas and Oil Engines, A. M. Levin. *Power*, April 2, 1912. 4 pp., 5 figs., 1 curve. *d.*

Features of valve and reversing gears now in use on the smaller types of engines.

Turbine, The Gas, Norman Davey. *The Engineer* (London), March 8, 22, 1912. 4 pp., 4 figs., 2 curves. *dhmA.* To be continued.

Theoretical principles of the gas turbine, the air turbine, air turbine with external combustion, the closed cycle air turbine, the open cycle, internal-combustion in which the expansion takes place above the atmosphere, and internal-combustion turbines in which the expansion takes place below the atmosphere.

Twin Screw Motor Ship Selandia, Description of the. *The Engineer* (London), March 8, 15, 22, 1912. 7 pp., 8 figs., one 2-page plate. *dpA.*

Size of ship, 370 ft. long by 73 ft. beam and 7400 ton capacity; engines: 1250-h.p., 8-cycle, 4-cylinder, Diesel type.

REPORTS OF MEETINGS

ENGINEERS DINNER AT PROVIDENCE

The Providence Association of Mechanical Engineers, affiliated with the Society, gave a dinner on March 26 in the Narragansett Hotel, which was attended by more than a hundred guests. Prof. Ira N. Hollis of Harvard University, senior vice-president of the Society, represented Dr. Humphreys, who was unable to attend, and extended the greetings of the membership and Council.

Professor Hollis was followed by Calvin W. Rice, Secretary of the Society, who spoke of the Society's activities and of its increased helpfulness and usefulness, by which it desired to benefit not only the membership but, in a modest way, the profession at large. He urged the participation of engineers generally in public affairs where engineering was involved and pointed out the especial need for development of foreign commerce. The balance of trade with South America is against the United States by over $100,000,000 gold annually, and is increasing from year to year.

Mr. E. L. Corthell, the speaker of the evening, was then introduced and made an eloquent address on the Future of South America, where he had spent many years of his life, giving many personal reminiscences of his work for the governments of South America, including the building of jetties, levees, and railroads. In conclusion, he announced a gift to Brown University, of which he is an alumnus, of his entire engineering library of over 7000 volumes, all bound in half morocco, and of provision for the continuance in perpetuity of subscriptions to the proceedings of all the 39 learned and engineering societies, both in America and abroad, of which he is a member.

PHILADELPHIA MEETING, MARCH 30

At a meeting of the Society in Philadelphia on March 30, a paper was read on an Ideal Flour Mill by B. W. Dedrick, instructor in milling engineering, Pennsylvania State College. This meeting was held at a time when there was a board meeting in Philadelphia of the Pennsylvania Millers' Association, so that the Society had the benefit of the discussion of those in attendance at this meeting. In the afternoon a visit was made to the Milburn Mills, Philadelphia, one of the oldest in the country. An abstract of the paper is published in this issue of The Journal.

SAN FRANCISCO MEETING, APRIL 3

At a meeting of the Society in San Francisco on April 3, a paper upon the Design and Mechanical Features of the California Gold Dredge, by

R. E. Cranston, was discussed. An account of the meeting will be published in an early issue of The Journal.

ST. LOUIS MEETING, APRIL 13

At a meeting on April 13 in the Chapel of the Second Baptist Church, held under the auspices of the Society, the Associated Engineering Societies of St. Louis coöperating, Dr. Rudolph Diesel of Munich, inventor of the Diesel oil engine, gave an illustrated lecture on the Development of the Diesel Engine, before an audience of over 500.

NEW HAVEN MEETING, APRIL 17

A meeting of the Society was held in New Haven, Conn., on the afternoon and evening of April 17, Manufacturing Costs being the general topic for consideration. The plan of a two-session meeting was tried by the New Haven members at a meeting last November, with such satisfactory results that this second meeting followed the same methods. The registration showed an attendance of 134 at the professional sessions held in the Mason Laboratory of the Sheffield Scientific School, and more than sixty were entertained at dinner at six o'clock at the Yale Dining Club. Considerable interest was manifested in the exhibition of some Gridley automatic turret lathes now in operation in the laboratory through the coöperation of the Windsor Machine Company.

The papers read at the afternoon session were The Development of Manufacturing Costs, by Prof. J. W. Roe, Mem.Am.Soc.M.E., assistant at Sheffield Scientific School, and Manufacturing Costs, by Bruce Fenn of Sargent & Company, New Haven. These were discussed by W. S. Huson, Mem.Am.Soc.M.E., general superintendent of the Whitlock Printing Press Manufacturing Company, Derby, Conn.; George W. Mixter, Mem.Am.Soc. M.E., vice-president of Deere & Company, Moline, Ill., and E. S. Cooley, Mem.Am.Soc.M.E., supervisor of power plants, N.Y., N.H. & H.R.R. Company, New Haven.

At the evening session a paper on the Cost Department and Its Relation to the Management, by G. P. Miller, secretary of the Bridgeport Brass Company, Bridgeport, Conn., was discussed by C. T. Raymond, Bridgeport, Conn.; E. W. Pelton, New Britain, Conn.; Arthur Brewer, Mem.Am.Soc. M.E., superintendent of the plant of the Bridgeport Brass Company; E. J. Mehren, New York; J. W. Roe, Mem.Am.Soc.M.E., New Haven; R. T. Kent, Junior Am.Soc.M.E., editor of Industrial Engineering, New York; M. W. Judge, Waterbury, Conn.; P. B. Stanley, New Britain; G. A. Kilborn, New Haven; Chas. F. Scott, Mem.Am.Soc.M.E., professor of electrical engineering, Yale University.

PROCEEDINGS OF THIRD NATIONAL CONSERVATION CONGRESS

The Executive Committee of the National Conservation Congress has decided to throw the reserve supply of the official addresses and proceedings of the Third National Conservation Congress open to the public. These are the only publications that record authoritatively the advance of the great conservation movement. They contain the speeches of President Taft.

Colonel Roosevelt, Gifford Pinchot, James R. Garfield, and other men of national reputation, as well as the reports of the state conservation commissions and of the conservation committees of national associations. As reference books on conservation they are invaluable.

As soon as the present limited supply is exhausted no more can be had at any price. While the supply lasts the complete set will be sent for $3, or $1 a volume, prepaid. On account of the limited supply it is probable that only early orders can be filled. Orders may be addressed to Thomas R. Shipp, Executive Secretary, National Conservation Congress, Indianapolis, Ind., with checks made payable to D. A. Latchaw, Treasurer.

STUDENT BRANCHES

ARMOUR INSTITUTE OF TECHNOLOGY

At a meeting held April 9 by the Armour Institute of Technology Student Branch the following officers were elected for the coming year: chairman, E. R. Burley; vice-chairman, J. D. Bradford; secretary, H. R. Kuehn; treasurer, A. Robertson. A paper on Oil Engines was also read by J. C. Miller and discussed by I. Newman and A. J. Beerbaum. The adaptability of the oil engine for power purposes was treated with regard to its reliability and the cost of operation and maintenance. Some of the most successful oil engines, such as the Diesel and De La Vergne types, were described in detail with the aid of a large number of lantern slides.

COLUMBIA UNIVERSITY

The Student Branch of Columbia University held a meeting March 29, at which P. Wood read a paper on Power Steering Gears on Modern Steamships.

On April 12, two papers were presented: Layout for a Manufacturing Plant, by B. Rogowski; and Precision Measuring Instruments, by B. Emmert. Discussion was offered by Messrs. Eddison, Thurston, Brombacker and Demorest. Professor Rautenstrauch and Messrs. Parr, Thurston and Herrick also gave short talks.

CORNELL UNIVERSITY

C. C. Anthony, Cornell 1886, assistant signal engineer of the Pennsylvania Railroad and son of Professor Anthony who founded at Cornell University the first course in electrical engineering in this country, spoke on Railway Signaling for Intensive Operation before a meeting of the Sibley College Student Branch April 11.

On March 15 Calvin W. Rice, Secretary Am.Soc.M.E., spoke on the Advantage of Membership in Student Sections of the Engineering Societies, and on March 29 J. C. Bishop read an original paper on Cement Manufacturing. The paper was commented on by Prof. R. C. Carpenter. A general discussion followed.

MASSACHUSETTS INSTITUTE OF TECHNOLOGY

On March 19 the Mechanical Engineering Society of the Massachusetts Institute of Technology held its annual banquet and election of officers at

the Boston City Club. The officers are as follows: chairman, J. G. Russell; vice-chairman, H. D. Peck; secretary, J. B. Farwell; treasurer, L. L. Custer; governing committee, E. W. Brewster, W. H. Brotherton and M. L. Waterman. The speakers of the evening were Ira N. Hollis, I. E. Moultrop, R. E. Curtis, R. H. Rice and Prof. E. F. Miller, all members of the Society, and H. W. Hayward.

On April 3 the civil and mechanical engineering societies were addressed by James W. Nelson on High-Pressure Hydrostatic Machinery. After the discussion of many problems of construction and the manner in which they were overcome, lantern slides were shown, among which were some excellent pictures of the excavations and locks at Panama.

PENNSYLVANIA STATE COLLEGE

During his visit to the Pennsylvania State College on March 20, Calvin W. Rice, secretary of the Society, delivered two lectures, one to the entire engineering school when he dealt with the benefits to be derived from all engineering societies by its members, and another to the members of the mechanical engineering society, when he spoke more specifically concerning membership in the Society.

POLYTECHNIC INSTITUTE OF BROOKLYN

Edward A. Uehling read a paper on CO_2 Recorders before a meeting of the Polytechnic Institute Student Branch on March 30. Other speakers of the evening were Fred R. Low, F. W. Atkinson, G. A. Orrok, J. B. Chittenden and W. D. Ennis.

PURDUE UNIVERSITY

At a meeting of the Purdue University Student Branch on March 20, Prof. H. C. Peffer of the School of Chemical Engineering, spoke on Refractory Materials.

The meeting of April 3 was addressed by W. I. Battin of the Indiana Lighting Company, who spoke on The Manufacture and Distribution of Gas.

UNIVERSITY OF ARKANSAS

At a meeting of the Student Branch of the University of Arkansas held March 26, R. E. Thornton read a paper on Over-Speculation and Prof. W. N. Gladson read one on the Motor in the Machine Shop.

UNIVERSITY OF CINCINNATI

The University of Cincinnati Student Branch held an open meeting March 21, at which a lecture on Gears, Their Manufacture and Design, was given by Ralph E. Flanders, Assoc.Am.Soc.M.E. The discussion was led by John T. Rowell.

A meeting of the members was held March 26, and consisted of reviews of various current engineering periodicals by those in attendance.

UNIVERSITY OF ILLINOIS

The University of Illinois Student Branch held a meeting March 29, at which various methods of welding and their applications were discussed in papers by the following: Arc Welding, J. N. Todd; Flame Welding, A. L. Myers; Thermit Welding, A. H. Agaard. A general discussion followed.

On April 12 the section was affiliated with the Associated Engineering Societies of the university, the individuality of the branch remaining intact. The program included papers on the Muncie Oil Engine, by R. C. Chestnutt; and the Diesel Engine, by H. F. Crooks. A general discussion followed.

UNIVERSITY OF KANSAS

The Geology of the Earth's Crust by Professor Twenhoffel was the subject of the meeting of the University of Kansas Student Branch, March 7.

UNIVERSITY OF MISSOURI

A paper on Water Power, illustrated by lantern slides, was presented by H. E. Weaver and A. E. Pierce at a meeting of the University of Missouri Student Branch on March 20.

WASHINGTON UNIVERSITY

John Hunter, Mem.Am.Soc.M.E., gave an illustrated lecture on Central Power Plant Operation and Economy, with special reference to the Ashley Street plant of the Union Electric Light and Power Company, before the Washington University Student Branch on March 28. A general discussion followed.

YALE UNIVERSITY

At a meeting of the Yale University Student Branch on March 25, F. E. Booth read a paper on Railway Signaling. The lecture was fully illustrated by lantern slides showing the interlocking system as used by the Union Switch and Signal Company in the New York subway as well as in the systems of large railways.

At the meeting held on April 12, Dr. Alex. C. Humphreys, President of the Society, delivered an address concerning the position of the technical graduate upon leaving college.

NECROLOGY

HENRY W. SPANGLER

Henry W. Spangler was born at Carlisle, Pa., January 18, 1858. He was graduated with high rank at the United States Naval Academy in the class with two others who have attained to prominent positions in the field of engineering education, namely, Ira N. Hollis, head of the engineering department at Harvard University, and M. E. Cooley, dean of the department of engineering at the University of Michigan.

Professor Spangler was assistant engineer in the United States Navy from 1878 to 1889, although for about half of that period he was connected on detached service with the faculty of the University of Pennsylvania, first as assistant professor of mechanical engineering from 1881 to 1884, and from 1887 to 1889, and then as full professor, holding the Whitney professorship of dynamical engineering. During the Spanish-American War he served for a brief period as chief engineer in the United States Navy. With that exception he was in the service of the University of Pennsylvania as head of the mechanical and electrical engineering department continuously from 1887 till his death.

He was the author of a number of standard textbooks and numerous technical papers and professional reports. The textbooks from his pen embrace Valve Gears; Notes on Thermodynamics; Elements of Steam Engineering, which he wrote in collaboration with A. M. Greene and S. M. Marshall; Graphics; and Applied Thermodynamics. He was a member of the American Society of Naval Architects and Marine Engineers, the American Society of Naval Engineers, the American Society for Testing Materials, and the Society for the Promotion of Engineering Education, the Franklin Institute and the Engineers Club of Philadelphia. He was a member of the Advisory Council of the Engineering Congress of the World's Columbian Exposition in 1893 and of the Jury of Awards at the Buffalo Exposition in 1901.

In 1896 the University of Pennsylvania conferred upon him the

honorary degree of Master of Science and ten years later the degree of Doctor of Science. He died March 17, 1912, at his home in Philadelphia.

Edgar Marburg, professor of civil engineering at the University of Pennsylvania, pays him the following tribute:

As a writer, his chief characteristics were, perhaps, his painstaking efforts to present the subject in the simplest and clearest manner consistent with the intended scope of treatment, and to keep in view the practical requirements of prospective engineers, rather than theorists.

As a teacher, he was lucid, stimulating, progressive, and always intensely practical. His first concern was to help the students to gain a firm grasp of the underlying principles of the subject, and then to encourage them to rely on their own resources in the application of these principles. On no point, perhaps, was he more insistent than that of individual responsibility, which his students were required to assume in every branch of their work.

A strict and almost military disciplinarian, he was no less rigid in the standards which he applied to himself. The respect and admiration in which he was held by his students ripened into affection as they came to see him at closer range. There were few graduates who failed to turn to him at some time for helpful counsel in the perplexities of later years, or who failed to accept it, even though it ran counter to their own promptings.

He possessed to a remarkable degree the faculty of perceiving clearly, and almost intuitively, the essential elements of a seemingly difficult problem or complex situation, and he was as quick in action as in perception. Few excelled him in the clear discernment of the fallacies of an argument or in the directness of the challenge of such fallacies. Of a thoroughly progressive bent, he did not allow himself to be beguiled into strange paths by the educational fads and follies of the hour. The business of education was to him a serious business, with which liberties were not to be taken lightly.

EDWARD S. RENWICK

Edward S. Renwick, who died March 19, 1912, was born January 3, 1823, in New York, and when thirteen years of age entered Columbia University, the youngest member of his class. After graduation in 1839 he engaged in the manufacture of iron with the New Jersey Iron Company at Boonton, as assistant and bookkeeper to the superintendent. In 1844 he was employed to examine and report upon some mines in Maryland and was afterward sent to England to attend to matters appertaining to them. Here he had the opportunity to examine the best iron works in both England and Wales. In the fall of 1845 he returned to America and became superintendent of the Wyoming Iron Works at Wilkes-Barre, Pa., which comprised a merchant mill for rolling bars, a sheet mill, a mill for rods and hoops and a nail factory. He also put up a small blast furnace in the same town and engaged in the manufacture of pig iron. In the spring of

1849 Mr. Renwick went to Washington and associated himself with Peter H. Watson, subsequently Assistant Secretary of War under Stanton during the Lincoln adminstration, in the business of solicitor of patents and expert in patent causes in the United States Courts. While at Washington he made several inventions, the most important of which was the original self-binding reaping machine, which cut the grain, gathered it into gavels, compressed it, and bound it into sheaves, with wire, but preferably with twine. It remained dormant, however, until the seventies, after the expiration of the patents, when the impossibility of obtaining sufficient laborers to harvest grain in the old way forced it into use. This invention, with small improvements, has yielded millions to the makers of reaping machines, and has added untold wealth to the country.

In December 1854 Mr. Renwick returned to New York, and his first employment was as consulting engineer to Harrison Gray Dyer, who had become president pro tem of the New Haven Railroad. His employment in this position terminated with the resignation of Mr. Dyer and he resumed the practice of his profession as patent expert and consulting engineer. The most important engineering matter in which he was called upon to act was the repair of the Great Eastern steamer while afloat. This consisted in covering with iron plating a fracture of the bilge 27 feet beneath the water, 28 feet long and 10 feet 6 inches broad at its widest part, a feat declared impossible by other experts. He did the work in conjunction with his brother, Henry B. Renwick.

From 1865 Mr. Renwick's employment as expert in patent causes was continuous. He had probably been subjected to the longest cross-examinations of any expert. Thus in one of his early cases his cross-examination lasted twenty-one days, with the result that the United States Circuit Court and afterward the United States Supreme Court on appeal, adopted the construction of the patent given by him in favor of the defendant. In another case the cross-examination by the complainant's counsel was carried on in sessions of from one to three days separated by intervals, the whole amounting to twenty-two days running through six months, when the case was compromised for $15. In the Leffel waterwheel case he was cross-examined thirty-five days, the decision of the court being in favor of the plaintiff on whose behalf he had been called as expert.

Mr. Renwick was greatly interested in artificial incubation, and it was due largely to his efforts and inventions that the raising of

young chickens was rendered a paying industry. He was also responsible for many other inventions, among which are the balanced compound steam engine, and the system of surrounding that portion of the shaft of a twin propeller which extends beyond the vessel with a casing of sufficient size to permit this portion of the shaft to be inspected to the stern bearing. Both of these are described in his English Patent of 1868. The former invention did not come into use until the last decade of the last century; and the latter until the accident to one of the shafts of the City of Paris, since which it has been employed in all the great sea-going steamers with twin screws. In 1893 Mr. Renwick published his work on Patentable Inventions, which has been called the only sensible treatise ever written on the subject.

He was a member of the American Chemical Society, the Engineers Club, the Union Club, the New York Yacht Club, the St. Nicholas Society and other similar organizations.

LEE D. FISHER

Lee D. Fisher was born December 22, 1875, at Elyria, Ohio, and died February 8, 1912, at his home in Joliet, Ill. In 1897 he was graduated from Washington University as an electrical and mechanical engineer and accepted a position as boiler and elevator inspector for the Union Casualty and Surety Company of St. Louis. Four months later he was transferred to the company's New York office. When the Spanish-American War broke out he was appointed chief assistant engineer on the flagship New York and later was transferred to the transport Buffalo in charge of the engine room, making a trip to Manila, where he was temporarily assigned to shore duty as engineer in charge of fortifications during the insurrection of Aguinaldo. He returned to the United States on the Buffalo as chief engineer.

Mr. Fisher joined his father in 1900 in electric railroad building out of Columbus, Ohio, serving as chief engineer in the construction of three roads radiating from that city. In 1903 he aided in building the Joliet, Plainfield and Aurora Railroad and the Joliet and Southern Traction Company's line. In 1911 he accepted service with the Public Service Company of Northern Illinois, having charge of franchise matters for the company until last October, when he was made assistant to the vice-president and placed in charge of the publicity department of that corporation.

EMPLOYMENT BULLETIN

The Society considers it a special obligation and pleasant duty to be the medium of securing better positions for its members. The Secretary gives this his personal attention and is most anxious to receive requests both for positions and for men available. Notices are not repeated except upon special request. Copy for the Bulletin must be in hand before the 12th of the month. The list of men available is made up of members of the Society, and these are on file in the Society office, together with names of other good men not members of the Society, who are capable of filling responsible positions. Information will be sent upon application.

POSITIONS AVAILABLE

0160 Works superintendent for plant employing 350 men, manufacturing heavy machinery, Corliss engines, etc. Superintendent must be competent to take full charge of entire plant. Apply through Am. Soc. M. E.

0161 Technical graduate having practical experience as an executive in charge of engineering department of a manufacturing plant, or as assistant to such an executive, wanted by Ohio concern. Familiarity with modern systems of management, construction of industrial and mining cars, design and construction of commercial auto trucks.

0162 Engineer experienced in automobile engine design and owning patent on silent sliding-valve engine which he believes has superior merit over best types now known, desires to interest capital to develop same.

0163 Mechanical draftsman experienced in the design of motors, generators and detail apparatus, such as controllers, switchboards, circuit breakers, etc. State experience and salary expected. Only first class men need apply. (Address Chief Clerk, Engineering Department, Westinghouse Elec. and Mfg. Co., E. Pittsburgh, Pa.)

0164 Mechanical engineer to collaborate with inventor in commercial development of a new cycle engine and later to manage the manufacturing end of the business. Man somewhat experienced in thermodynamics and ambitious to assist in promoting to the fullest extent the development of the mechanical end of the business, so that one would be preferred who can take a pecuniary interest in the business.

0165 Manufacturing executive for concern in New England, manufacturing electrical hardware, switches, cutouts, etc., small growing concern well supplied financially; executive with brains, experience and tireless energy. Salary $5000 upward according to man. Apply through Am. Soc. M. E.

MEN AVAILABLE

406 Works manager, long experience on light manufacturing involving in-

terchangeable parts. Competent to organize all departments of manufacturing plant along modern lines.

407 Mechanical engineer, age 34, technical graduate, four years' experience in design and construction of steam engines, two years' superintendent of engine works, three years' construction and complete power plant installation; desires position with sales, construction or manufacturing concern.

408 Mechanical and electrical engineer; graduate University of Pennsylvania, desires position in connection with sales department. Practical experience covers sales, mechanical design, charge of drafting room, foreman in machine shop and individual work on various machine tools. Detailed information and references given upon request.

409 Junior member of the Society, holding degrees of S.B. and M.M.E., four years' teaching experience and two years' engineering practice; desires position on instructing staff of mechanical department of some college.

410 Junior member, technical graduate, age 26, married, experienced in machine shop, automatic machine design, miscellaneous engineering work; now employed, but desires to locate with a reliable concern with opportunity to advance. Can furnish the best of references of character, ability, reliability, etc.

411 Graduate Mass. Inst. Tech., 25 years of age, experienced in drafting and designing of special machinery and buildings for foundry, machine shop, rolling mill and special manufacturers, shop experience and in the manufacture of steel office, bank and library furniture and floors. Desires position in the mechanical engineering line in or near Spokane, preferably that of assistant to manager or superintendent.

412 Position as manager of small growing factory desired by mechanical engineer, 32 years old, technical graduate, three years' experience as machinist apprentice, two years' drafting, four years' production and industrial engineering installing shop and cost systems, rearranging and equipping plants for increased efficiency. Familiar with laying out new plants and electrical installations. At present general superintendent of factory employing 150 to 200 men. In charge of manufacturing, production, factory accounting, and costs.

413 Member, with extensive experience in large machine and tool manufacturing plants, finest and most accurate classes of precision work to the heaviest; thorough practical knowledge of tools, machinery, equipment, modern shop practice organization and management, seeks connection as superintendent, master mechanic or factory manager where there is real need of man who can do things. Salary not less than $3000 and can earn more.

414 Junior, technical graduate, 32 years old, married, ten years' practical experience, mostly steel mills. At present district sales manager in Middle West; desires change requiring less traveling. Would like to interest party with capital in complete engineering sales line for Birmingham District.

415 Member, experienced in design, construction, operation and testing, gas and oil engines, steam engines, compressors, pumps and general power plant work; good shop man. Formerly chief engineer for old established firm; now

connected with one of largest universities in the country. Desires to secure position from June 1 to October 1.

416 Member, mechanical engineer, Cornell graduate, having 12 years' experience in designing automobile, stationary and marine internal-combustion engines; desires position.

417 Member, graduate mechanical engineer, with extensive experience in manufacturing interchangeable machinery. Specially good experience in the design of machinery, jigs, and fixtures for the production of duplicate parts, also in testing, handling and use of glues and adhesives. Present position mechanical engineer with large wood and iron working factory. Wishes position as superintendent.

418 Technical graduate with 18 years' experience in shop, drafting room, office and teaching in mechanical engineering, the last including executive work, would like to change. Desires to become connected with consulting engineer or with engineering department in college or university.

419 Member, technical education and wide experience in different kinds of mills, steam engineering and modern machine shop practice, desires position as superintendent, master mechanic or chief engineer of power plant.

420 Young mechanical engineer, technical graduate, experienced along lines of building steam piping, design and erection, desires position offering chance of advancement with engineering firm engaged in similar work. Good references.

ACCESSIONS TO THE LIBRARY

With Comments by the Librarian

This list includes only accessions to the library of this Society. Lists of accessions to the libraries of the A. I. E. E. and A. I. M. E. can be secured on request from Calvin W. Rice, Secretary Am. Soc. M. E.

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UNITED ENGINEERING SOCIETY

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EXTRACTS FROM THE BOOK OF THE

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Multi-stop and Double Turners

FIG. 1 illustrates the advantage of the *double stop* for each position of the turret, and the *double* adjustment of each turner. This piece has six finished diameters and six shoulders, and is turned by only three turners, which occupy only three positions on the turret. This not only leaves the remaining positions free for other tools, but it saves the operator the time and energy required to run the turret slide back each time.

All this is obtained without complication, and without introducing any features that are annoying when not in use.

In addition to the double stop for each of the six positions of the turret, we have an extra stop, consisting of a pin which may be dropped into any one of the six holes at the rear of the turret slide. This makes it possible to borrow five extra stops for any one of the tools, and gives to this tool seven length or shoulder stops, and leaves one stop for each of the remaining tools.

FIG. 1

The illustrations, Figs. 2 and 3, give examples of what one tool can do in this machine on chuck work, when we take advantage of the seven length stops and the seven shoulder stops of the cross-feed head.

Of course, in general practice three or four stops for one tool are all that will be needed, but since the modern cutting steels have greater durability, there is nothing lost by giving each tool all the work it can do.

Outer face and all shoulders and diameters accurately finished to independent stops by one tool. When roughing and finishing cuts are required, the roughing tool can be set near enough to use the same stops that are accurately set for the finishing tool. When an extra tool is used to give a roughing cut it is set as indicated by dotted lines in Figs. 2 and 3.

We find it difficult to illustrate all of the classes of work that can be turned out by this machine, but a little thought will suggest

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HARTNESS FLAT TURRET LATHE

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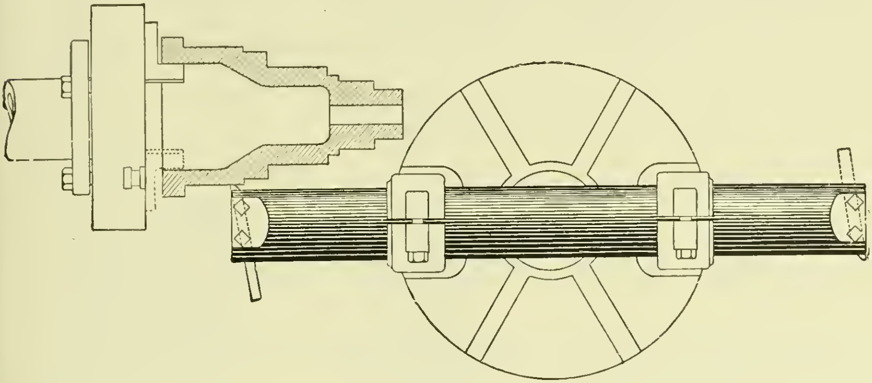


FIG. 2

many forms that may be readily handled in bar and chucking work, both steel and iron, on account of the many provisions for bringing both turret and cross slide up to fixed stops; either by power feed or by hand.

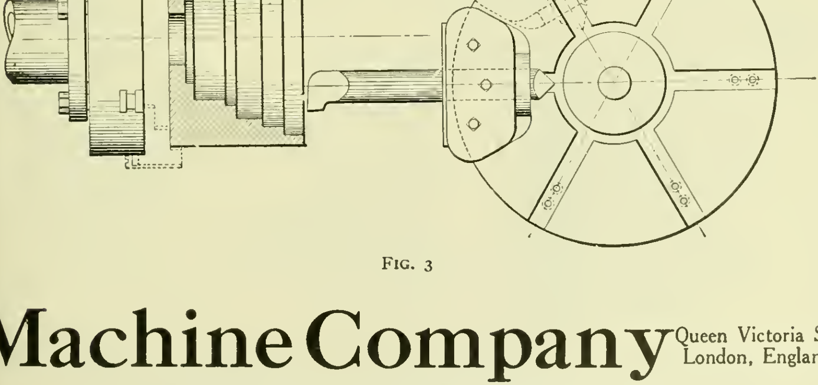
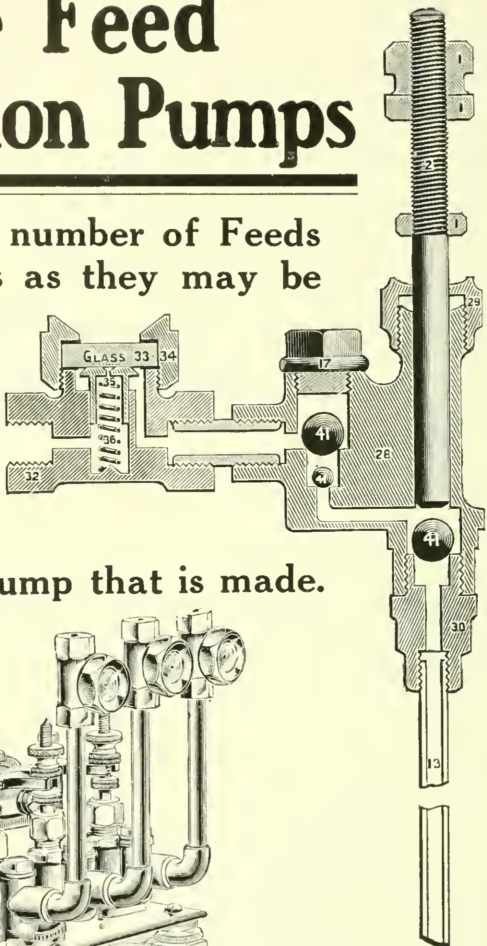


FIG. 3

Force Feed Lubrication Pumps

are made in any number of Feeds or compartments as they may be ordered.

¶ The most substantial, simplest in construction and reasonable in price of any pump that is made.



SECTIONAL VIEW OF PUMP USED ON OUR FORCE FEED LUBRICATING PUMPS

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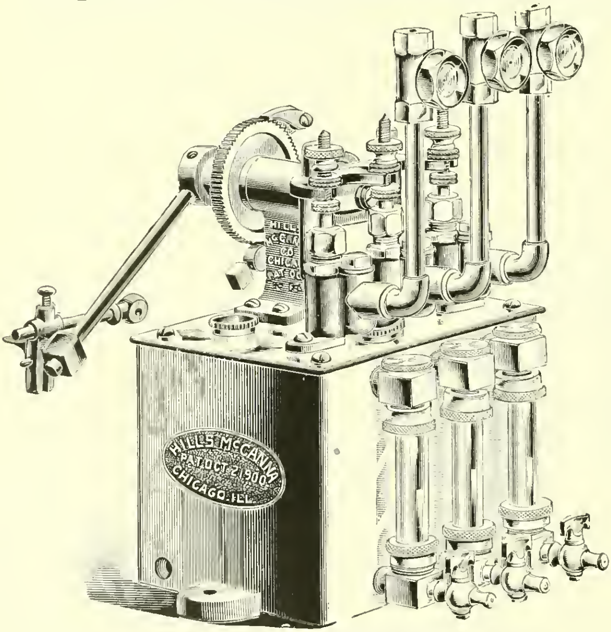

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Gland on Medium and Extra Heavy valves.

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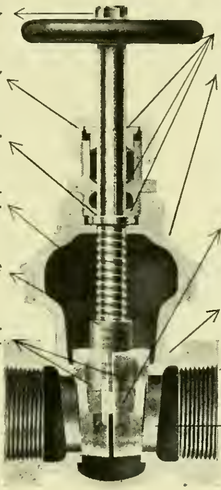
Threads. Scientifically and mechanically correct, strong, wear well, easy to operate.

Wedge. The only spreading device in the valve. *One piece.* Simple.

Discs. Two. Simple. Compact. Can't get out of order. Automatically rock into perfect alignment with the seats, not only when the seats are new, but should the seats become distorted from their original angle, through sagging of the pipe or otherwise, the discs will still *make up tight* with the seats.



Stem has bearing at *three* points, keeping the stem central and steady.

Bonnet. Screwed on outside of body on Medium and Extra Heavy valves, strengthening it for severe service. The outside bonnet is not used on Standard valves, as the body is made so strongly that it is not required for 125 pounds working pressure.

Disc Guides. These guide the discs freely, making operation easy, *no binding at any point*, prevent discs from scraping on the seats.

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Threads. Cut *taper*, to standard gauges, for good, tight, pipe connection.

100% opening, *no obstructions.*

Hexagons unusually long and very heavy.

Outside view of Standard Valve

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Medium, for 175 pounds working pressure.
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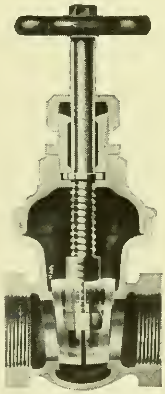

Inside view of Standard Valve

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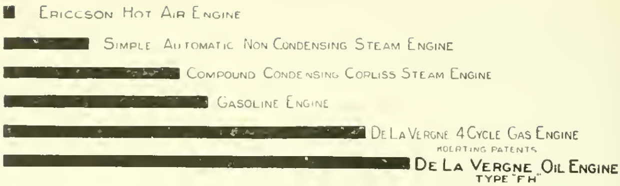

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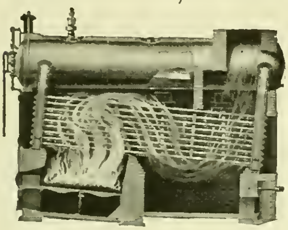

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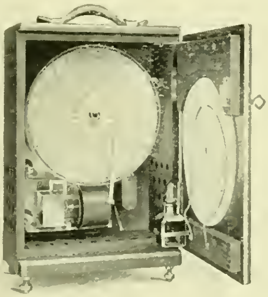

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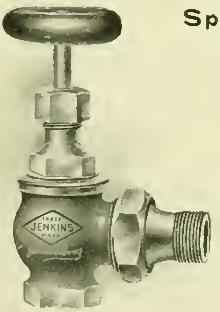

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DEPARTMENT OF ENGINEERING. Civil, Mechanical, Electrical and Chemical Engineering. New laboratories and excellent equipment. Beautiful site within four miles of Boston. Preparatory department for students who have had engineering practice, but insufficient preparation for college work. For information concerning courses and positions of graduates, address

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CONDENSED CATALOGUES OF MECHANICAL EQUIPMENT

SECTION ONE

Power Plant Equipment

Other sections of the Condensed Catalogues to be published in subsequent issues of The Journal during 1912 will include Hoisting, Elevating and Conveying Machinery, Industrial Railway Equipment, Power Transmission Machinery, Electrical Equipment, Metal Working Machinery, Machine Shop and Foundry Equipment, Steel and Rolling Mill Equipment, Pumping Machinery, Mining and Metallurgical Equipment, Heating and Ventilating Apparatus, Refrigerating Machinery, Air Compressors and Pneumatic Tools, Engineering Miscellany.

THE AMERICAN SOCIETY *of* MECHANICAL ENGINEERS

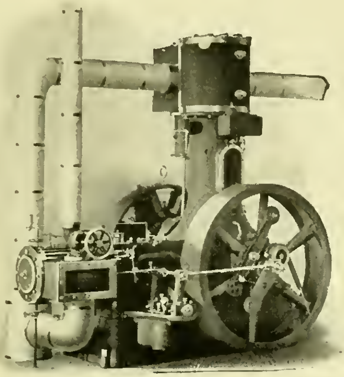
AMERICAN ENGINE COMPANY

42 RARITAN AVENUE

BOUND BROOK, N. J.

ALL KINDS OF HIGH GRADE SIMPLE AND COMPOUND STEAM ENGINES, DIRECT-CONNECTED UNITS, MOTORS AND GENERATORS.

THE AMERICAN-BALL ANGLE COMPOUND ENGINE



The American-Ball Angle Compound Engine has all of the advantages possessed by every American engine, an automatic system of lubrication, sensitive balanced automatic governor, adjustable cross head guides, attached indicator reducing motion, high-class workmanship, etc. Besides these, some of the special advantages inherent to the angle construction are as follows:

(1) With the cylinders at right angles, practically perfect balancing is secured.

(2) The angle construction, with its four impulses per revolution, gives a practically uniform torque, making this engine especially adaptable for driving alternators which are to be run in parallel.

(3) With no dead centers, the engine can be started from any position.

(4) Small floor space. The Angle Compound Engine gets twice as much power on the same amount of floor space as does a simple engine.

These matters are fully discussed, with appropriate diagrams, in our pamphlet on "The Modern High-Speed Automatic Engine."

The American-Ball Angle Compound Engine has been widely adopted for generating power in isolated plants.

We have prepared a special report on the cost of isolated plant power, which we will be pleased to send to engineers interested in this branch of engineering.

DIMENSIONS OF AMERICAN-BALL ANGLE COMPOUND ENGINES

FOR BELTED SERVICE								FOR DIRECT-CONNECTED SERVICE								
Horsepower	Cylinder Diameters and Stroke	Revolutions per Minute	Floor Space Length	Floor Space Width	Steam and Exhaust Pipes Steam	Steam and Exhaust Pipes Exhaust	Shipping Weight Pound	K. W.	Cylinder Diameters and Stroke	Revolutions per Minute	Floor Space Length	Floor Space Width	Steam and Exhaust Pipes Steam	Steam and Exhaust Pipes Exhaust	Shipping Weight in Pounds Direct Connected Engine	Shipping Weight in Pounds Engine and Dynamo
120	12 & 19 x 10	325	103	85	4	6	12,000	75	12 & 19 x 10	325	103	107½	4	6	12,200	17,000
160	13 & 20 x 11	300	111	93½	4	7	14,900	100	13 & 20 x 11	300	111	112	4	7	15,200	21,100
250	16 & 25 x 12	285	125	110	6	9	23,000	150	16 & 25 x 12	285	125	120½	6	9	21,400	32,200
325	18 & 28 x 14	260	138	126	6	10	30,000	200	18 & 28 x 14	260	138	132½	6	10	27,900	40,000
400	20 & 32 x 15	250	145	141	7	12	37,600	250	20 & 32 x 15	250	145	156½	7	12	31,700	45,000
500	22 & 34 x 16	240	154	158	8	12	45,000	300	22 & 34 x 16	240	154	165	8	12	39,200	
650	25 & 38 x 18	225	164	182	9	14	59,000	400	25 & 38 x 18	225	164	174	9	14	51,000	

BALL ENGINE CO.

ERIE, PENNSYLVANIA

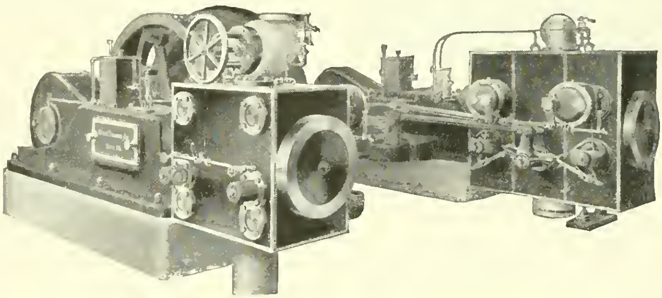
CORLISS-VALVE AND SINGLE-VALVE ENGINES; HORIZONTAL AND VERTICAL SIDE-CRANK ENGINES; TANDEM AND CROSS-COMPOUND SINGLE-VALVE ENGINES, CORLISS-VALVE COMPOUND AND SINGLE-CYLINDER ENGINES.

HIGH-SPEED CORLISS ENGINES

The feature which distinguishes this engine from other four-valve shaft governed engines is the patented non-detaching valve gear, which imparts the same movement to the valves that the drop cut-off of the slow-speed Corliss produces by picking up and dropping them. This permits the use of the best form of valve, and the valves are given the movement necessary for the greatest durability and tightness.

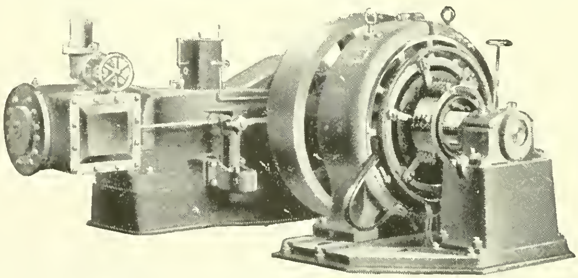
Built in sizes from 100 h.p. to 1200 h.p. in the single-cylinder and cross-compound types.

These engines excel in economy and regulation and are especially adapted for electric service.



SINGLE-VALVE AUTOMATIC ENGINES

These engines are the result of a long experience in building engines for electric service. They are superior in design and construction. The regulation and economy are the best of their type.

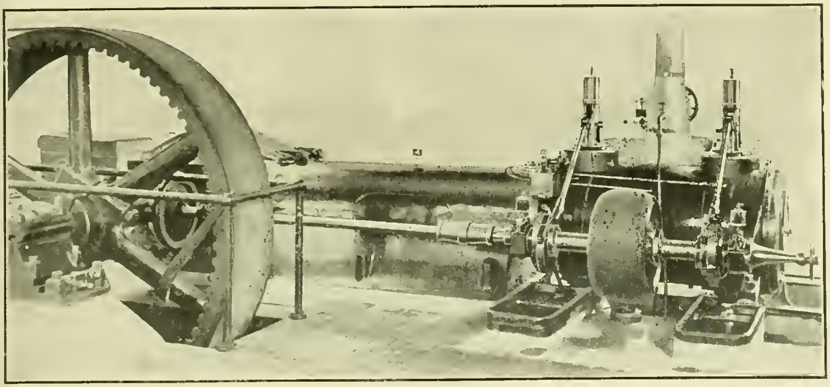


Built in sizes from 25 h.p. to 800 h.p. in the single-cylinder, tandem-compound and cross-compound types.

ERIE CITY IRON WORKS

ERIE, PENNA.

STEAM ENGINES AND BOILERS. FEED WATER HEATERS. HORIZONTAL AND VERTICAL WATER TUBE BOILERS. LENTZ ENGINES.



The Lentz Engine

A PROVISION FOR THE NECESSITY CONFRONTING AMERICAN MANUFACTURERS FOR ECONOMY IN THE USE OF FUEL

We are approaching a condition in this country that exists in other countries, that is: *extreme economy must be practised in every department of every business to make a fair showing*, and this applies with especial force to the coal pile.

After an extended investigation we have become convinced that the Lentz engine, using superheated steam is the most economical of all prime movers, and have secured the American rights for manufacturing it under the patents of Hugo Lentz, of Germany.

CONSTRUCTIONAL FEATURES

Throughout the engine there is no elastic packing used. The valves are of the double-seated poppet type, and the valve spindles are ground to fit in long bushings with water grooves, and no packing is used in this construction. The valve is so designed that it can stand high temperature or changes of temperature without affecting its tightness, and as there is no rubbing surface it stands equally well under a high degree of superheat or saturated steam. The valves are actuated by a cam working on a roller, these parts being all case hardened. When the valve comes to a seat the cam is disengaged, but the roller and cam are always in contact until the valve has been seated, consequently, there is no noise, nor is there any limit to the revolutions at which the valve gear may be run.

The governor is extremely simple in its construction; consisting of an inertia weight, two pendulæ and one small flat spring. It utilizes its inertia in a very novel and unique manner. The outer ring, running loose on the lay shaft instead of being rigidly connected to it, as is the case in most other governors, influences directly the governor spring and the pendulæ. With the slightest change of load and consequently of speed, this inertia force acts before the centrifugal forces which have to first overcome the friction existing before they can possibly become operative. The consequence of this novel combination of inertia and centrifugal action is a greatly increased sensitiveness and quickness in action.

When required, the engine is provided with a hand-speed adjustment, and the speed of the engine can be varied while in operation. As noted in the illustration herewith, the engine is extremely simple and very accessible. All details have been fully patented by Mr. Hugo Lentz of Germany, and we have the exclusive rights under these patents in the United States.

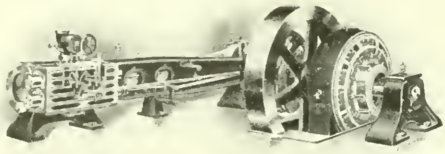
We are prepared to demonstrate that this is the most economical steam engine that has ever been made. We have offices in all the important centers, and it would be a pleasure for us to have a representative call and go into the details of this engine. This engine is built single cylinder, tandem and cross-compound.

THE FITCHBURG STEAM ENGINE CO.

FITCHBURG, MASS.

SINCE 1870 MANUFACTURERS OF STEAM ENGINES
FOR USE UNDER EVERY SORT OF CONDITION

"THE FITCHBURG"—DIRECT-CONNECTED—GIRDER BED

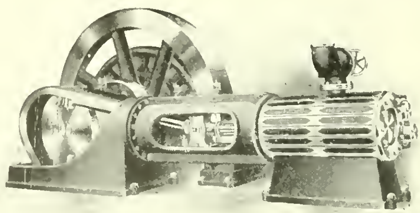


Sizes 7″ by 18″ to 22″ by 42″. Revolutions 80 to 250.

D. Con. or Belted	Girder Bed as above	To	300	H.P.
" " "	Tangye Bed as below	"	800	"
" " "	Tandem Girder	"	300	"
" " "	Tandem Tangye	"	800	"
" " "	Cross Girder	"	750	"
" " "	Cross Tangye	"	1500	"
" " "	High-Speed Horizontals	"	250	"
" " "	Single Cylinder Vertical	"	400	"
" " "	Steeple Comp'd Vertical	"	400	"

Details for any size given on application.

"THE FITCHBURG"—DIRECT-CONNECTED—TANGYE BED



Sizes 12″ by 18″ to 30″ by 48″. Revolutions 80 to 250.

HEWES & PHILLIPS IRON WORKS

Established 1845

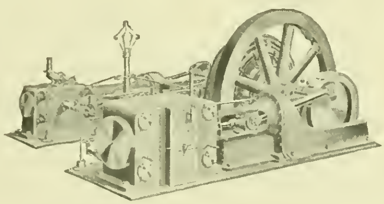
NEWARK, N. J.

CONTRACTING ENGINEERS AND MANUFACTURERS OF PATENT DOUBLE-PORTED CORLISS ENGINES, SIMPLE OR COMPOUND, CONDENSING AND NON-CONDENSING FOR EITHER BELTED OR DIRECT-CONNECTED ELECTRICAL DRIVES. EQUIPPED WITH FRANKLIN PATENT HORIZONTAL GRAVITY-LATCH RELEASING VALVE GEAR

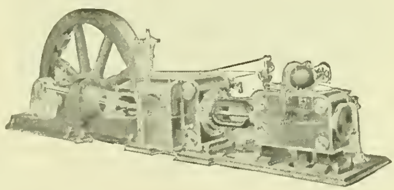
Also CORLISS FOUR-VALVE ENGINES, NON-RELEASING TYPE. Equipped with Robb-Armstrong-Sweet Inertia Shaft Governor, Automatic Unit-Tank Oiling and Filtering System. SPECIALLY DESIGNED AND CONSTRUCTED FOR DIRECT-CONNECTED ELECTRICAL INSTALLATIONS IN COMMERCIAL BUILDINGS

NAYLOR VORTEX STEAM SEPARATORS
INDEPENDENT STEAM-DRIVEN VENTURI AIR PUMPS AND CONDENSERS

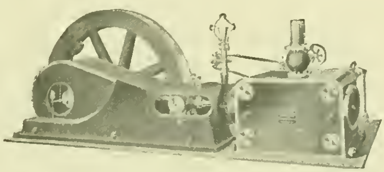
BAROMETRIC CONDENSERS
HEAVY IRON AND BRASS CASTINGS
COMPLETE STEAM POWER PLANTS A SPECIALTY



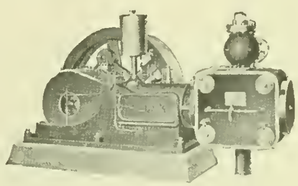
Cross Compound Heavy-Duty Engine
Rotative Speed 100 to 150 Rev Per Min



Tandem Compound Heavy-Duty Engine
Rotative Speed 100 to 150 Rev. Per Min



FRANKLIN
Corliss Heavy-Duty Engine, Releasing Valve Gear. Rotative Speed 150 to 200 Rev. Per Min.



AJAX
Corliss Four-Valve Engine, Inertia Shaft Governor. Rotative Speed 200 to 250 Rev. Per Min

For further information and details send for Catalogue

HARDIE-TYNES MANUFACTURING COMPANY

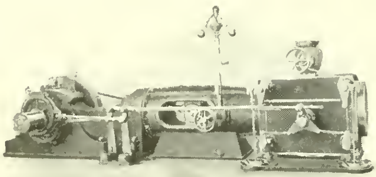
BIRMINGHAM, ALA.

CORLISS ENGINES, AUTOMATIC ENGINES, HOISTING ENGINES, DIRECT-CONNECTED ENGINES, SLIDE VALVE ENGINES, BAROMETRIC CONDENSERS, AIR COMPRESSORS, SPECIAL MACHINERY, HEAVY CASTINGS.

Several types of Corliss Engines are built to meet the requirements of all classes of manufacturing and public service plants.

All similar parts are interchangeable. Materials are those best suited for the service for which they are intended. Workmanship is of that high order found only in a well organized plant building high grade machinery.

Bulletins illustrating them may be had on application.

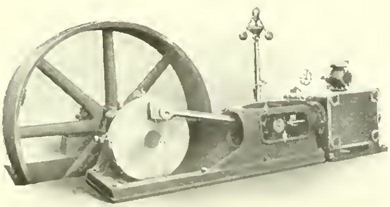


HEAVY DUTY CORLISS ENGINES

Tangye Frame Type

Designed for steam pressures of 150 lb. or more, to run at moderate speeds.

Built for either direct-connected or belted service, in sizes ranging from 16 x 36 in., 114 i.h.p., to 34 x 60 in., 1255 i.h.p.



HEAVY DUTY CORLISS ENGINES

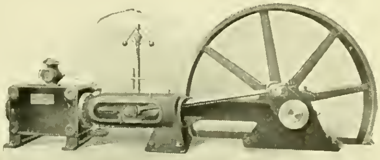
Imperial Frame Type

These engines are also designed for steam pressures of 150 lb. or more, but may be operated at somewhat higher rotative speeds than the Tangye Frame Machines.

They are particularly desirable for electric power and lighting plants, requiring comparatively small powers. Sizes range from 8 x 20 in., 21 i.h.p., to 22 x 30 in., 550 i.h.p.

HARDIE-TYNES MANUFACTURING COMPANY

HEAVY GIRDER FRAME CORLISS ENGINES

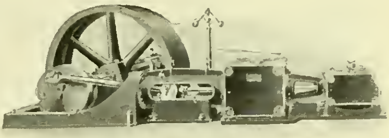


These engines are especially suitable for manufacturing plants having moderate steam pressures and no suddenly applied overloads.

Designed for steam pressures of 150 lb. or less, and built in sizes ranging from 12 x 24 in., 52 i.h.p., to 26 x 48 in., 780 i.h.p.

COMPOUND CORLISS ENGINES

Cross and Tandem Types



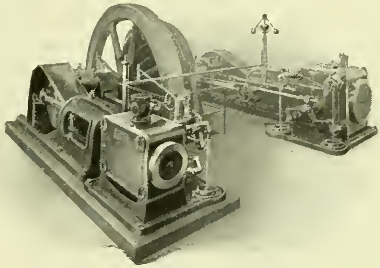
Cross and Tandem Compound Engines are built on either Tangye, Imperial or Girder Frames, in the following sizes:

Tangye Frames 16 and 36 x 36 in., 400 i.h.p., to 34 and 68 x 60 in., 2300 i.h.p.

Imperial Frames 8 and 16 x 20 in., 65 i.h.p., to 22 and 44 x 30 in., 700 i.h.p.

Girder Frames 12 and 24 x 24 in., 135 i.h.p., to 26 and 52 x 48 in., 1300 i.h.p.

DIRECT-CONNECTED CORLISS ENGINES

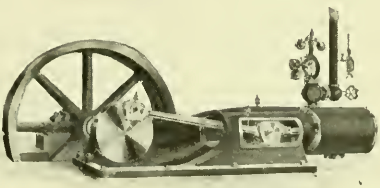


Both Tangye and Imperial Frame Engines are built for service with direct-connected generators.

Sizes and speeds are suitable for generators ranging in power from 50 kw. to 1500 kw.

BALANCED VALVE ENGINES

Heavy Duty Type



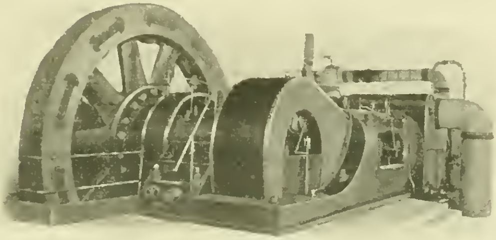
In many industries, such as saw mills, coal mines, etc., waste material is available for fuel, and the question of economy gives place to that of simplicity and low first cost.

In such cases our heavy duty balanced valve engine is a most satisfactory power producer. In design of frame, bearings, and reciprocating parts, it resembles the highest type of Corliss engines more nearly than its competitors.

Twelve single cylinder sizes ranging from 10 in. x 14 in, 39 i.h.p., to 24 in. x 30 in., 455 i.h.p.

Twelve twin cylinder sizes ranging from 10 in. x 14 in., 78 i.h.p., to 24 in. x 30 in., 910 i.h.p.

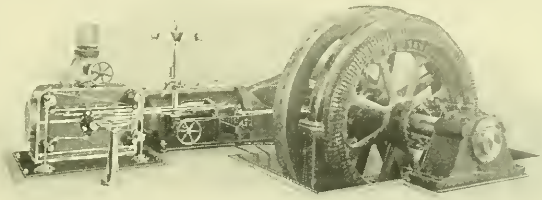
THE HOOVEN, OWENS, RENTSCHLER COMPANY



Tandem Compound Corliss Rolling Mill Engine

TANDEM COMPOUND HAMILTON HIGH SPEED CORLISS ENGINE WITH VARIABLE SPEED VALVE GEAR

This engine is equipped with positive driven valve gear and link motion with variable speed hand regulating cut-off mechanism and is arranged for direct connection to centrifugal pump or blower. It is provided with a fly ball governor, attached to a quick closing auxiliary throttle valve. The frame used in this engine is of same design as our heavy duty engine and the speed is usually from 125 to 175 RPM.



Single Cylinder Direct-Connected Corliss Engine

SINGLE CYLINDER AND COMPOUND HAMILTON HIGH SPEED CORLISS ENGINE WITH NON-RELEASING VALVE GEAR

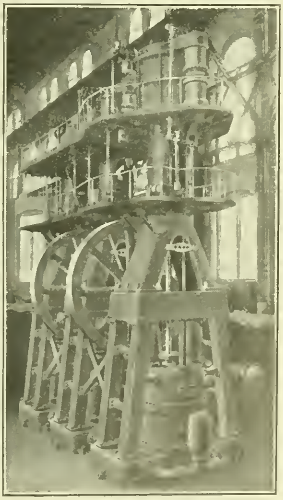
This engine is adapted for all speeds from 125 to 200 RPM. It is made from our regular Corliss patterns, with changes in the valve gears to meet the demand for higher speeds than are possible with the releasing gear and dash pots.

This engine is entirely in a class by itself and is different from the so-called "four valve engine." The valve movement is as near the regular Corliss movement as it is possible to make, without a hook and dash pot release. The mechanism is such that the valves move during the balanced period, giving highest economy and least wear. The rocker arms, etc., are as light as possible consistent with strength, reducing inertia forces to a minimum.

The valve stems are equipped with special spherical metallic packing of our own design (patented), eliminating the use of stuffing boxes. The entire valve gear sets close to the cylinder, as shown in the illustration.

The governor used on this engine is of the shaft type (patented) and is different from any other manufactured. It is arranged so that the governor weights, springs and eccentrics are in perfect gravity balance at all speeds, making it possible to equalize the steam distribution in each end of the cylinder. Another feature of importance is that the spring is attached to the weight in such a manner that its force and the centrifugal force of the weight are nearly opposite, making the resultant force and the wear on the weight pin very small indeed.

Every detail of our engines receives great care and is fully described in our bulletins issued at frequent intervals.

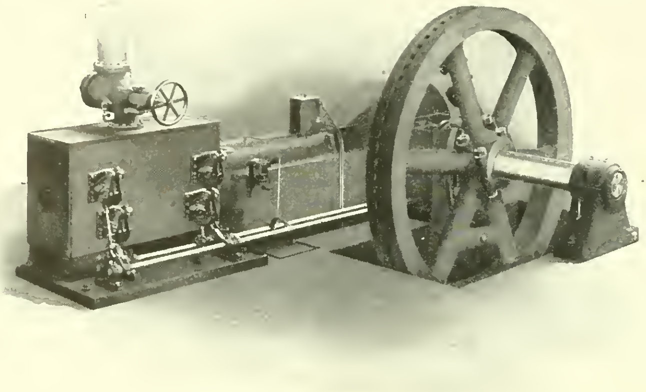


23 Million Gallon High Duty Pumping Engine

McINTOSH & SEYMOUR CO.

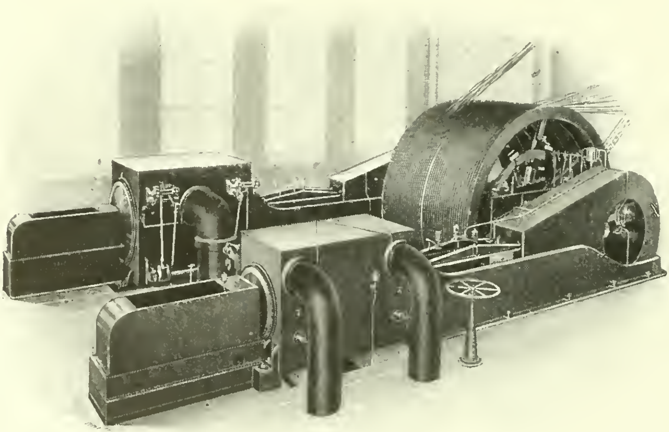
AUBURN, N. Y., U. S. A.

MANUFACTURERS OF GRIDIRON VALVE STEAM ENGINES IN ALL STYLES. SINGLE-CYLINDER, COMPOUND, OR TRIPLE EXPANSION TYPES



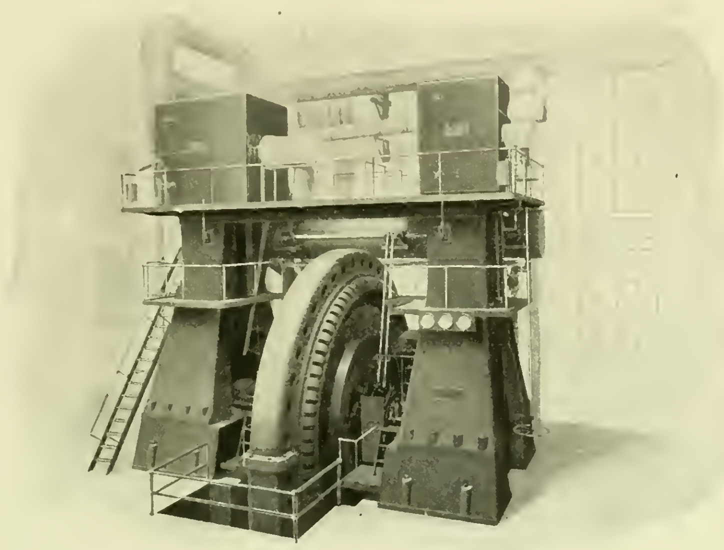
Type F Horizontal Engines. 150 to 1200 H. P.

This is a modern, positive-feed self-oiling, enclosed type of engine recently introduced with marked success. The extreme simplicity is the result of improvements suggested by twenty years' experience in building gridiron valve engines. This makes the engine less expensive and also makes it desirable to extend the range of sizes to smaller powers and higher speeds without sacrificing any of the advantages of this type in the line of sustained economy, durability, and good running qualities.

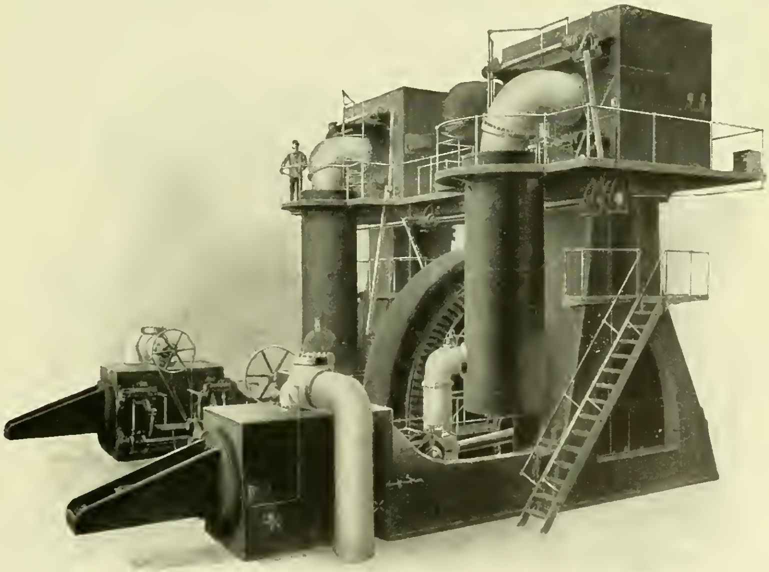


Horizontal Engines. 250 to 4000 H. P.

McINTOSH & SEYMOUR CO.



Vertical Engines. 250 to 4500 H. P.



Combined Horizontal-Vertical Engines. 750 to 9000 H. P.

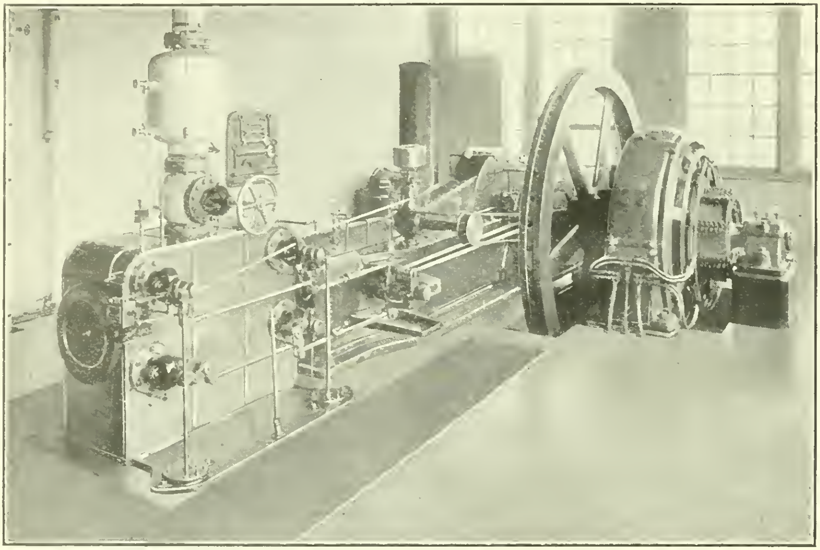
This is a patented type of engine which possesses peculiar advantages for many locations, and also where very large units are desired.

Also Horizontal High Speed Piston Valve Engines of from 25 to 500 H. P.

PROVIDENCE ENGINEERING WORKS

PROVIDENCE, R. I.

RICE & SARGENT STEAM ENGINES. REPAIRS TO IMPROVED GREENE ENGINES. SPECIAL MACHINERY.



The Rice & Sargent Corliss Engines are built in all usual types, for all purposes for which a high grade Corliss engine is required. They are built in all sizes, from 150 Horse Power to the largest desired. They are designed throughout for speeds considerably higher than are usual for other Corliss engines, making them especially suited to direct-connected electrical work.

Rice & Sargent Corliss Engines are built in one grade only—The same patterns, material and workmanship are used on every engine as on those installed in some of the country's finest steam plants.

Remarkable results have been obtained in a number of very accurate tests both as regards steam consumption, regulation and mechanical efficiency.

Bulletins describing the details of construction and the result of tests will be sent to anyone.

TROY ENGINE & MACHINE CO.

TROY, PENNSYLVANIA

STEAM ENGINES OF THE CENTRE-CRANK TYPE EXCLUSIVELY

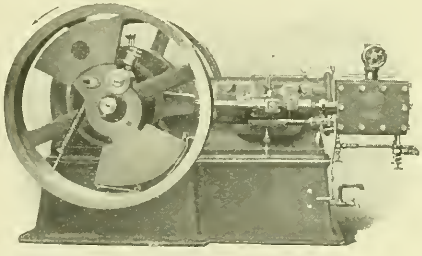
Our standard products are given in the list below. Column B gives the maximum usual pressure and Column C the number of sizes made.

Stock Title	B	C
Troy Vertical Automatic Engines	80–160	13
Troy Horizontal Automatic Engines	80–160	8
Troy Vertical Direct-Connected Engines	80–160	13
Troy Horizontal Direct-Connected Engines	80–160	8
Troy Vertical Throttling Engines	80–160	14
Troy Horizontal Throttling Engines	80–160	9
Troy Vertical Low-Pressure Engines	10– 40	10
Troy Horizontal Low-Pressure Engines	10– 40	6

All the above are made either enclosed and self-oiling, or open with gravity lubrication.
Sizes — 2 to 100 H. P.

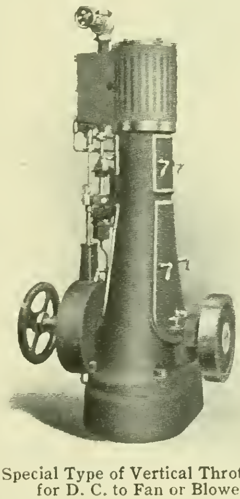
TROY SELF-OILING ENGINES

Troy Self-oiling Engines have been tested at Cornell University, disclosing high mechanical efficiency and a very low rate of water consumption. These are features of practical interest to the purchaser for they insure an important saving in the cost of operation.



Horizontal Automatic Type
for Belted Service

This excellent showing is due to the original design of the engine, as well as the skill and care exercised in its manufacture. The engines are built to give long service with minimum expense for maintenance.



Special Type of Vertical Throttling
for D. C. to Fan or Blower

The Troy Engine has—

A self-oiling system that saves oil and relieves the engineer of many duties necessary for the ordinary engine. The system has a pump and a check valve that are always dependable.

A balanced valve that is steam tight and self-adjusting to prevent leakage. This valve will not have to be replaced or repaired.

There are other features of interest and all are described in an engine catalogue. We shall be glad to furnish complete data relative to any of our engines that may interest you. An opportunity will be appreciated to explain what the Troy Engines will do for you and how they will save you money on your investment.

THE MURRAY IRON WORKS CO.

BURLINGTON, IOWA

BUILDERS OF CORLISS ENGINES; PUMPING ENGINES; AIR COMPRESSORS; FEED WATER HEATERS; BOILERS; AND CONTRACTORS FOR COMPLETE POWER PLANTS.

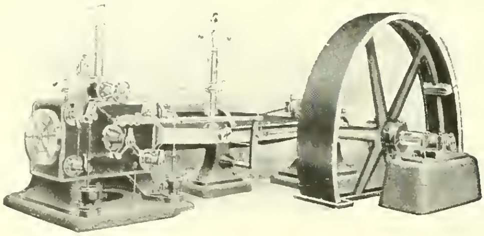
MURRAY CORLISS ENGINES

Murray Corliss Engines are built either with girder frames, tangye frames, or rolling mill frames of our patented design. The Standard Murray Corliss is a girder-frame engine built in capacities ranging from 50 to 600 indicated horsepower. Tandem and cross-compound engines are built for any load required.

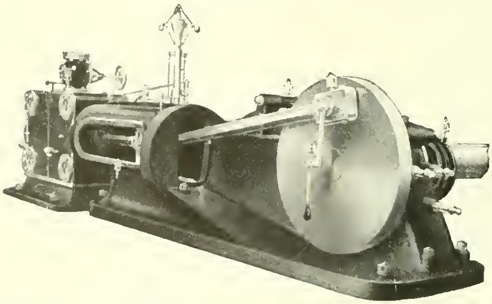
CONSTRUCTION DETAILS

Material and workmanship are of the best and inspection is most rigid at every stage of construction. Governor is of high-speed ball-bearing type, with improved safety stops. Cylinder has exhaust passages insulated from cylinder by dead air space. Valves, valve motion, dash pots and piston are all of improved patterns. Fly wheels made in halves, free from initial strains. Pillow block vertically adjustable with oil-retaining rim.

Broad pyramidal main bearing and cylinder feet or sole plates. Connecting rod and cross head are of improved pattern and the clearance volume has been reduced to a minimum. Many working parts are ground.



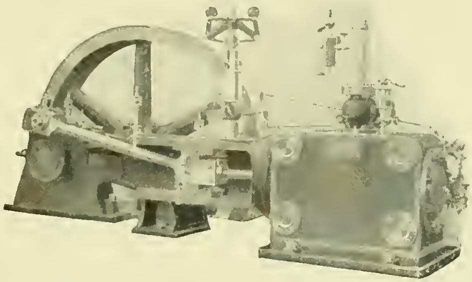
Standard Murray Corliss Engine



Murray Rolling Mill Type Engine

MURRAY-MINOR CORLISS ENGINE—20 to 50 H. P.

Suitable for day loads in small electric plants and for the smaller mills and factories

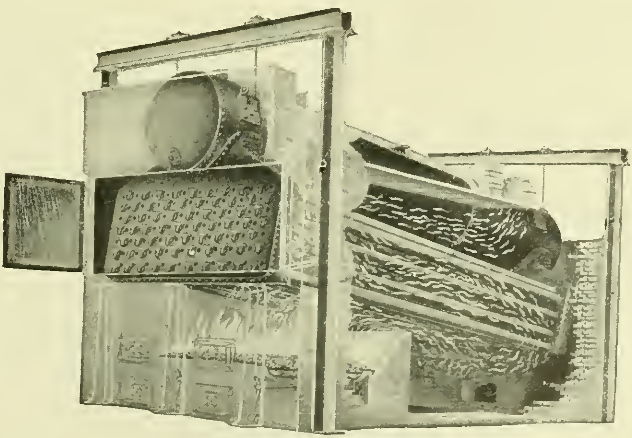


MURRAY SAFETY WATER TUBE BOILER

Our boiler consists of one or two top drums with front and rear headers all entirely constructed of boiler plate, with a number of wrought tubes connecting the headers. The drums incline to the rear, and headers are carefully and strongly riveted to drums, the tubes being expanded into both headers.

Free circulation of water and steam is provided for by having all connections of ample size. An internal mud drum is provided for removing impurities from the water, this drum being provided with necessary blow-off cocks. Our boilers are inspected and insured by boiler insurance companies.

The setting is designed upon proved lines of construction which an ordinary mason can execute properly. Murray rocking grates are furnished.

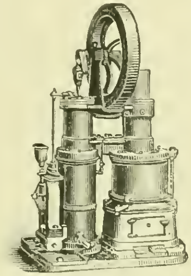


Murray Water Tube Boiler

RIDER-ERICSSON ENGINE COMPANY

NEW YORK BOSTON PHILADELPHIA MONTREAL
SYDNEY, AUSTRALIA

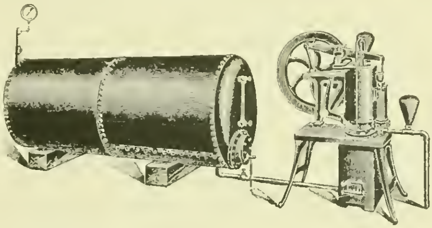
"REECO" RIDER HOT-AIR PUMPING ENGINES. "REECO" ERICSSON HOT AIR PUMPING ENGINES. "REECO" ELECTRIC PUMPS.



"Reeco" Rider Hot-Air Pumping Engine

THE "REECO" RIDER HOT-AIR PUMPING ENGINE

Is especially adapted for somewhat heavy domestic work where water has to be pumped from deep wells or forced to a great height. It uses every kind of solid and liquid fuel. More than 20,000 in operation.



"Reeco" Ericsson Hot-Air Pumping Engine

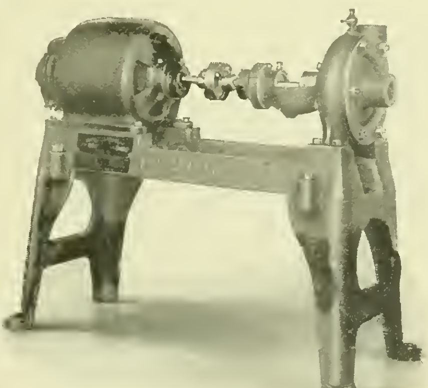
THE "REECO" ERICSSON HOT-AIR PUMPING ENGINE

(Invention of Captain John Ericsson)

Is especially adapted for lighter work such as pumping for seashore or suburban cottages, hotels, etc.

About 30,000 in operation.

The simplest known form of power pump. Uses all kinds of liquid and solid fuel.



"Reeco" Centrifugal Pump, Motor and Belt Drive. (Legs shown in cut are used only in connection with 1" motor driven pump.)

THE "REECO" CENTRIFUGAL PUMP

Made for both motor and belt drives, provided with outboard, ring-oil bearings, with removable bushings and flanged machined couplings.

Catalogues in English, French, German, Portuguese and Spanish.

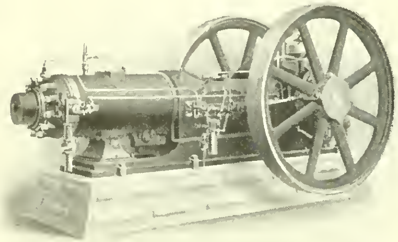
THE BESSEMER GAS ENGINE CO.

GROVE CITY, PA.

BUILDERS OF BESSEMER CRUDE OIL ENGINES, BESSEMER GAS ENGINES, BESSEMER KEROSENE ENGINES, BESSEMER DIRECT GAS ENGINE DRIVEN AIR AND GAS COMPRESSORS, BESSEMER DIRECT DRIVEN PUMPS, BESSEMER BELT DRIVEN COMPRESSORS, BESSEMER REVERSE CLUTCHES. BUILDERS OF COMPLETE POWER PLANTS.

THE BESSEMER GAS AND CRUDE OIL ENGINES

2 H. P. to 350 H. P.



The Bessemer Crude Oil Engine, Single Cylinder.

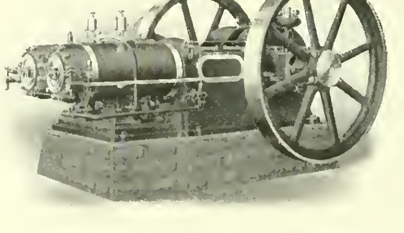
Bessemer Gas Engines are two stroke cycle receiving a power impulse every revolution of the crank for each cylinder used. A single cylinder Bessemer equals in power impulses a two cylinder four stroke cycle engine, accomplishing the same or better results with less than half the usual number of parts. The two cylinder Bessemer equals the steam engine in impulses per revolution and gives, with the throttling governor used, a regulation not excelled. The Bessemer is thus peculiarly adapted to electric light and power work or any installation in which steady operation is a factor.

Bessemer Crude Oil Engines operate on crude oil, fuel oil, solar oil, and low gravity distillates. They are engines without magnetos, sparker or batteries and operate smoothly and continuously without depositing carbon in combustion chamber.

Bessemer Engines are entirely distinct and different. They are built with enclosed crank case, with a crosshead, obviating the wear on cylinder which occurs in the trunk piston type of engine; have no valves exposed to the force and heat of exploding gases, hence no regrinding or valve troubles; splash and mechanical force feed lubrication, direct geared throttling governor, extra heavy and strong parts, wide adjustability for wear, making a strictly high grade engine that is securing the gas engine business wherever introduced.

Bessemer Engines are not experimental, there being over 11,000 in daily use. Single cylinder, twin cylinder and twin cylinder opposed types.

Send for catalogues, Blue Book of Bessemer Buyers and ask to be placed on mailing list to receive the Bessemer Monthly and Monthly Art Calendars as issued.



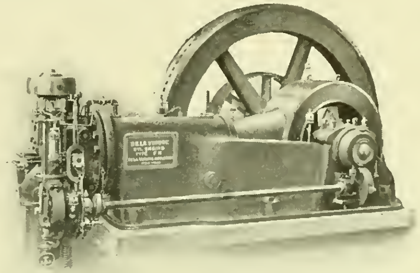
Twin Cylinder Bessemer Gas and Crude Oil Engine

DE LA VERGNE MACHINE CO.

1123 EAST 138TH STREET - - NEW YORK CITY

DE LA VERGNE CRUDE OIL ENGINES
GAS ENGINES ICE MACHINES

TYPE "FH" CRUDE OIL ENGINE



GUARANTEED:

To operate on the cheapest and heaviest grades of petroleum and crude oils, including those from the California and Texas fields with an asphaltum base.
To deliver the full rated Brake Horse Power not only at sea level but up to 5000 ft. altitude.
To consume not more than the following quantities of fuel per BHP hour:—

When running at ¾ to full load	0.6	lbs.
" " at ½ to ¾ "	0.65	"
" " at ¼ to ½ "	0.75	"

Operates at medium pressures.

Not more than 1½ gallons of lubricating oil per 1000 BHP hours ordinarily required.

Not more than 3 gallons of cooling water necessary per BHP hour.

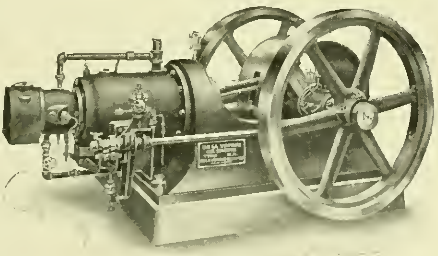
Reliable and satisfactory service with minimum expense for upkeep.

Manufactured in sizes of 90 HP. and over.

Type "FH" engines aggregating 15000 HP. in operation.

Detailed information in bulletin No. 112.

TYPE "HA" OIL ENGINE



GUARANTEED:

To operate satisfactorily on ordinary grades of distillates and fuel oils. To deliver the full rated Brake Horse Power. To consume not more than the following amounts of fuel per BHP hour:

When running at full load	1	lbs.
When running at ¾ load	1.12	"
When running at ½ load	1.35	"

In sizes from 10 HP. to 100 HP.

For detailed information see bulletin No. 111.

Both types are adapted to and used in all classes of service where reliability is of importance in addition to

Low Cost of Operation.

THE SMITH GAS POWER COMPANY
LEXINGTON, OHIO.

GAS PRODUCERS FOR POWER AND HEATING, SUCTION AND PRESSURE TYPES. SPECIAL DESIGNS FOR ANTHRACITE, BITUMINOUS AND LIGNITE COAL. TAR EXTRACTORS AND GAS CLEANING PLANTS.

STANDARD APPARATUS IS BUILT IN THREE TYPES: B, C AND E.

Type B.	Built in nine sizes.	From 50 H. P.	to 300 H. P.	for	Bituminous Coal.
Type C.	" " " "	" 50 "	" 300 "	"	Lignite Coal.
Type E.	" " eleven "	" 25 "	" 300 "	"	Anthracite Coal.

SPECIAL FEATURES OF THE DIFFERENT TYPES

Type B Producers are up-draft equipped with mechanical scrubbers. The design is such that in usual practise the tar made is not more than 1 to 3% by weight of the coal burned.

Type C Producers are down-draft equipped with mechanical scrubbers. The design is such that nearly all of the volatile contained in the lignite is converted into a fixed gas. Not necessary to shut down for cleaning. One 600 H. P. plant has been in operation two years without drawing the fire.

Type E Producers are up-draft equipped with static baffle scrubbers.

SPECIAL FEATURES COMMON TO SMITH PRODUCERS OF ALL TYPES

Patented automatic method of regulating the ratio of steam to air in the blast at all loads.

Flat swinging grates in smaller sizes—Shaking grates mechanically operated in larger sizes. Special facilities provided for removing ash from center of fire.

Low driving rate per sq. ft. of grate area so that the temperature of the fire will not reach the fusing point of the ash.

Deep fuel bed enables the producer to respond to sudden fluctuations in load.

Large fuel magazine obviates the necessity of frequent charging.

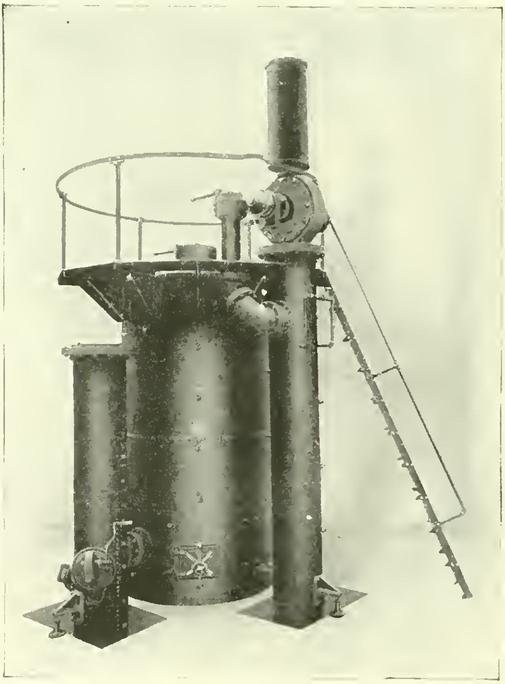
Charging Hopper design that prevents the admission of air to the top of the producer while charging.

The Static Baffle Scrubber is efficient, compact, and "fool proof."

Patented self-cleaning producer gas valves.

Piping. All connections to shells are made with solid cast iron flanged saddles riveted in place. Flanged fittings are used throughout. Flanges are made up permanently, the pipe being expanded and beaded into the flanges.

Special hot water boiler placed in the engine exhaust line acts as a silencer and furnishes moisture for the blast. Extra large boilers can be furnished in case hot water is wanted for heating buildings.



Smith Type B Suction Producers to operate on bituminous fuel

Exhausters and automatic pressure regulators furnished when it is desired to deliver gas under pressure to engines or for heating.

EDWIN BURHORN COMPANY

71 WALL STREET — NEW YORK CITY

WATER COOLING TOWERS. RIVETED PIPE.
INTERNALLY FIRED BOILERS.

BURHORN AND ACME COOLING TOWERS

The tower illustrated herewith is of the open type, as the majority of plants are so designed that this type will show maximum efficiency. We are prepared, however, to furnish cooling towers of the closed type embodying all the economical characteristics of the open towers, but provided with stacks for natural draft or equipped with fans for forced draft.

VALUE OF COOLING TOWERS

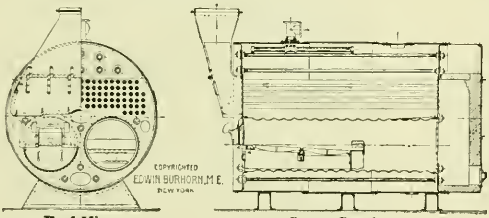
In any installation requiring water for cooling purposes a cooling tower is a valuable adjunct and a source of economy, unless there is available an abundant supply of cold, clean, pure water.

In many cases the use of water from the city supply would be perfectly satisfactory were it not for the excessive cost. By installing our cooling tower, however, only 2% to 5% of the water otherwise necessary will be required, and the cost of the supply is reduced proportionally.

CONSTRUCTION

Our towers are built of steel throughout and are practically indestructible. All parts are in plain sight and are readily accessible for inspection, cleaning, painting, etc.

Catalog on request.

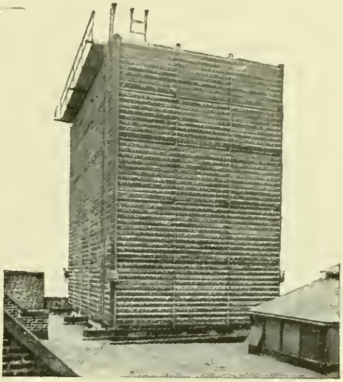


End View — Cross Section

INTERNALLY FIRED BOILER

DIMENSIONS OF STANDARD SIZES

Horse Power	Diameter	Length	Furnace	Number of Tubes	Diameter of Tubes	Length of Tubes	Combustion Chamber	Fire Brick Lining	Smoke Outlet Diam.	Steam Outlet	Safety Valve	Feed	Blow Off
75	78″	14′9″	36″	42	3½″	11′6″	24″	9″	20″	3″	2½	1¼	1½
100	84″	15′9″	38″	56	3½″	12′6″	24″	9″	23″	3½″	3	1¼	1½
125	90″	15′9″	45″	70	3½″	12′6″	24″	9″	26″	4″	3½	1½	2
150	96″	16′3″	50″	80	3½″	13′0″	24″	9″	28″	4½″	4	1½	2
200	114″	15′9″	2–38″	108	3½″	12′6″	24″	9″	33″	5″	4½	1½	2½
250	126″	15′9″	2–45″	137	3½″	12′6″	24″	9″	36″	6″	5	2	2½
300	138″	16′3″	2–50″	161	3½″	13′0″	24″	9″	40″	7″	5½	2	3



Water Cooling Tower

INTERNALLY FIRED BOILER

This type of boiler is compact, requires little head room as compared with other types of boiler, and recent tests have proved it as efficient and as suitable for high pressures as any type of water tube boiler. This type of boiler requires no brick setting, and has no water legs or other restricted place to become clogged with sediment. Every part of the interior is readily accessible and may be kept in a high state of efficiency.

Manufactured in seven standard sizes ranging from 75 to 300 h. p. Special sizes designed to meet special conditions.

Catalog on request.

RIVETED STEEL PIPE

The most apparent advantages of Riveted Pipe over Cast Iron in large sizes are·

Uniformity in thickness and material.

Absence of Blow holes.

No shrinkage strains.

Decreased freight and haulage charges.

Cheapened erection and handling cost.

Less resistance to flow of contents.

Safety from damage due to hidden defects.

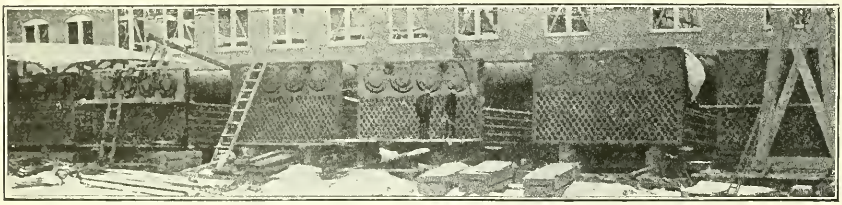
Catalog on request.

EDGE MOOR IRON COMPANY

EDGE MOOR, DELAWARE

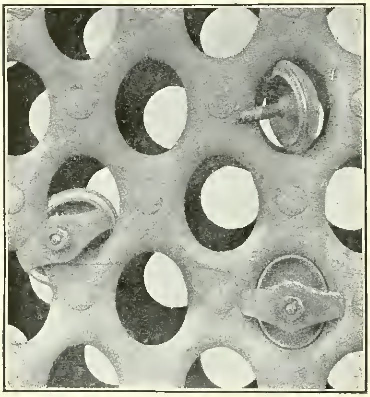
WATER TUBE BOILERS

Manufacturers of Water Tube Boilers, in four sections, consisting of front and back headers, drums and tubes. The construction of headers and their connection to drums is designed to avoid contraction of circulation at those parts.



Battery of 6 4-Drum Edge Moor Water-Tube Boilers in course of erection. W. Va. Pulp & Paper Mill, Covington, W. Va.

Surfaces and storage capacity is large and the boiler responds quickly to unusual demands and maintains a steady water line. Passing of gases may be arranged in several ways and any type of stoker or grate may be used. A sliding hearth plate facilitates cleaning fires. Superheaters may be connected in several ways and are designed to require little attention and no flooding. They add nothing to the width of setting. We are prepared to build boilers from 6 tubes wide up to 30 tubes wide and 6 to 16 tubes high, from 1 drum up to 5 drums and tubes 18′ to 20′ long. Typical Setting with 18-foot tubes has length over all of 20′10½″. Length of Furnace may vary in length from 60″ to 144″. Width of Furnace may vary per column A of table below. Height of Setting varies from 11′–10″ up to 20′–9″ overall. To determine width of setting for given H. P. add to dimension from Col. A 17″ each for side walls and 26″ for partition in double setting. Add 6″ each side for buckstays. Tubes draw front or rear.



Exterior view of hand-hole plate of header.

TABLE GIVING RANGE OF NOMINAL H.P.

For Different Widths of Setting

A	Horse Power	A	Horse Power
4′ 5″	100 to 210	12′ 1″	270 to 600
5′ 0½	115 " 240	12′ 9″	285 " 630
5′ 8″	125 " 270	13′ 4½″	300 " 660
6′ 4″	140 " 300	14′ 0″	315 " 700
6′ 11½″	155 " 340	14′ 8″	335 " 730
7′ 7½″	170 " 375	15′ 3½″	350 " 760
8′ 3″	180 " 405	15′ 11½″	360 " 790
8′ 10½″	200 " 435	16′ 7″	375 " 820
9′ 6½″	215 " 465	17′ 2½″	395 " 850
10′ 2″	230 " 505	17′ 10½″	410 " 880
10′ 9½″	245 " 535	18′ 6″	425 " 915
11′ 5½″	260 " 565	19′ 2″	435 " 945

HEINE SAFETY BOILER COMPANY

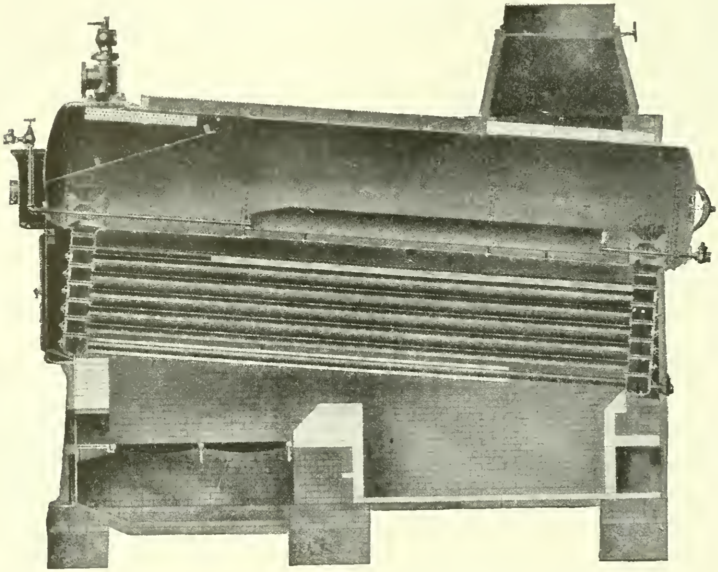
ST. LOUIS, MO.

SHOPS: St. Louis, Mo. Phoenixville, Pa.

New York
Cincinnati
Boston
Chicago
Pittsburgh
Philadelphia
New Orleans

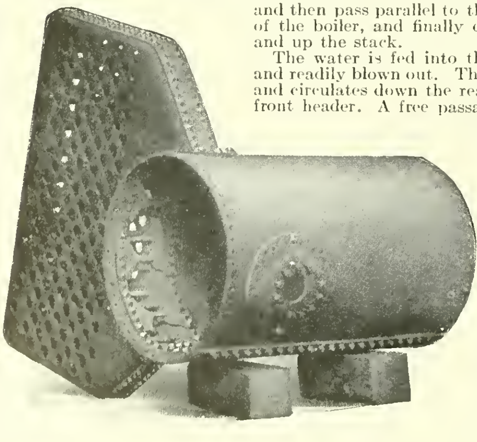
**HEINE SAFETY WATER TUBE BOILERS, HEINE PATENT STEAM SUPERHEATERS
STEEL STACKS, HOUSINGS, FLUES, ETC.**

THE HEINE BOILER



The Heine Boiler consists of three parts: the drum or shell, the front and rear headers and the tubes.

The partially consumed gases rising from the fuel bed are completely burned in the combustion chamber under the fire brick baffle placed on the lower row of tubes and then pass parallel to the boiler tubes from the rear to the front of the boiler, and finally over the upper baffle and under the shell and up the stack.



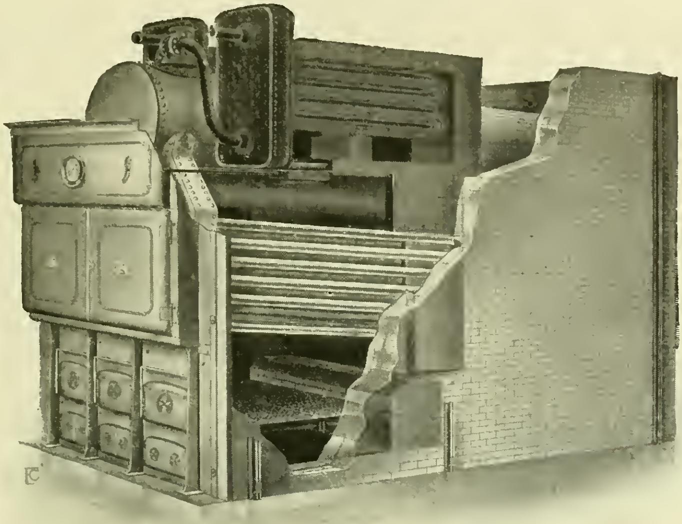
The water is fed into the mud drum where the sludge is deposited and readily blown out. The water rises out of the drum as it is heated and circulates down the rear header through the tubes and up the front header. A free passageway for the steam and water is provided by the large throat area at the junction of the boiler shell and the headers. This construction is shown at the left and is to be contrasted with those types of boilers in which the water circulation is badly congested.

This large throat area means dry steam, because the velocity of the steam is low, and therefore its capacity for carrying water is a minimum. Dry steam is further insured by providing a separator within the boiler. The steam must make a complete turn around the deflection plate, which may be seen in the illustration and it must make another complete turn in passing through the dry pan.

For further information regarding modern boiler practice, and the efficiency of the Heine Boiler, send for "Boiler Logic" and our book "Helios."

HEINE SAFETY BOILER COMPANY

THE HEINE SUPERHEATER

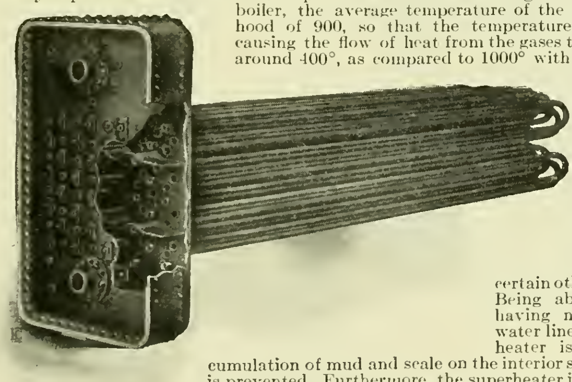


The Heine Superheater may be installed with any type of boiler in new or old installations. It consists of a header box into one side of which are inserted U tubes made of 1½″ seamless, drawn mild steel tubing, expanded into holes provided for them. The interior of the box is divided into three compartments, so that the steam makes three passes through the superheater.

The Heine Superheater is designed (a) to give close regulation of superheat, (b) to permit adjustment of the degree of superheat at any time, (c) to give maximum capacity per square foot of superheater surface, and (d) to give high efficiency in utilization of heat in the fuel. (It should be borne in mind that with all types of superheaters, regardless of their construction or method of installation, the superheating is secured from the heat in the combustion gases and represents fuel burned.)

The Heine Superheater is installed above the water line and to one side of the drum, and receives its heat from a small flue built in the side wall of the setting, which carries hot gases direct from the furnace to the superheater chamber, where they make two passes around the superheater tubes. The quantity of hot gas is controlled (automatically or by hand) by a damper at the outlet of the superheater and the temperature of the steam may be regulated to within 5° of any desired figure.

In the Heine Superheater large superheating capacity is secured, because the average temperature of the hot gases giving up heat to the superheater is about 1500°, whereas, with the ordinary superheater installed in the path of the combustion gases after the first pass of the boiler, the average temperature of the gases is in the neighborhood of 900, so that the temperature difference or heat head causing the flow of heat from the gases to the steam is somewhere around 400°, as compared to 1000° with the Heine Superheater. As the heat transmitted through a square foot of superheater surface is proportional to the temperature difference, it follows that each square foot of Heine Superheater surface has about double the capacity of the ordinary type.



The location of the Heine Superheater has certain other important advantages. Being above the water line and having no connection below the water line, no flooding of the superheater is necessary, and the accumulation of mud and scale on the interior surfaces of the superheater is prevented. Furthermore, the superheater is at all times accessible for inspection and cleaning, so that the surface may be kept clean. For further details send for "Superheater Logic" and "Helios."

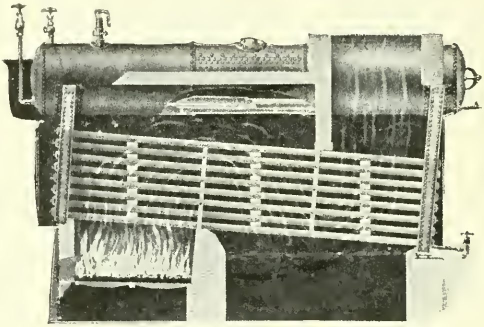
JOHN O'BRIEN BOILER WORKS CO.

ST. LOUIS, MO.

WATER TUBE, TUBULAR, FIRE-BOX AND INTERNALLY FIRED BOILERS. IMPROVED O'BRIEN-HAWLEY DOWN DRAFT FURNACES. SMOKE STACKS, TANKS AND SHEET IRON WORK.

WATER-TUBE BOILERS

Design B. Vertical Baffle



The boiler consists of one or more steam and water drums to which is securely riveted a front and rear water leg or header. The drums are perfectly level when the boiler is in position.

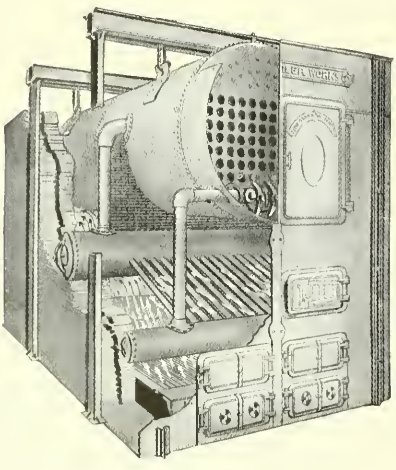
The tubes are expanded into the headers in straight horizontal and staggered vertical rows and are inclined 1″ to the foot. A greater pitch can be had if desired. The outside diameter of the tubes is $3\frac{1}{2}$″. We can furnish the 4″ outside diameter tubes if specified.

To meet all demands we build our boilers with either the vertical or horizontal baffle.

We also manufacture a water tube boiler with the drum set parallel with the tubes which, when in position, shows an incline of 1″ to the foot.

THE O'BRIEN-HAWLEY IMPROVED SMOKELESS DOWN-DRAFT FURNACE

Can be attached to any design of boiler



This furnace is constructed with two separate grates, one above the other. The upper grate is formed of a series of tubes opening at their ends into drums or manifolds through which the water of the boiler continually and rapidly circulates. The tubes form the fire grate. Air for combustion enters through fire doors near the top of the furnace.

The division wall at the back of the furnace deflects the draft down through the fire upon the upper grate and over the fire on the lower grate. The fire on the lower grate is entirely fed by coked coal falling from the upper grate and the unconsumed gases and smoke from the upper fire are efficiently burned by the lower fire.

The lower grates are of common bars accessible through flue doors for cleaning and spreading.

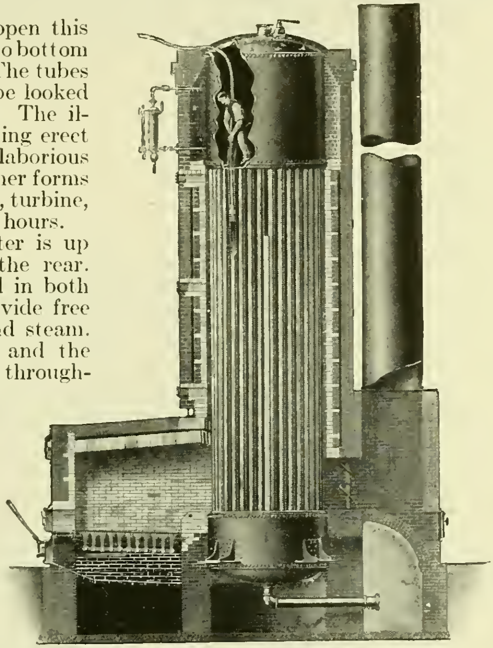
THE WICKES BOILER COMPANY

SAGINAW, MICHIGAN, U. S. A.

VERTICAL WATER TUBE BOILERS; HIGH GRADE RETURN TUBULAR BOILERS

These boilers are designed for delivering dry steam, for very easy cleaning and for high every-day thermal efficiency. The illustration gives a clear idea of the design, which consists, primarily, of upper and lower drums joined by perfectly straight boiler tubes.

The steam drum is arranged to give a height of 66" from water line to the dished head, upon which the steam outlet nozzle is riveted. This high drum serves several purposes. It provides room for separation from the steam of water which is always entrained with steam at a point close to the surface of liberation; it gives room for workmen to stand inside of the boiler when cleaning the tubes, and since the shell is subject to a mild degree of heat some superheat is effected upon the steam.



Two 12" x 16" manholes open this boiler, it is accessible from top to bottom for inspection and cleaning. The tubes are straight; every tube can be looked through, washed or scraped. The illustration shows a man standing erect using a turbine cleaner. Is it laborious compared with the work in other forms of boilers? Two men can open, turbine, close and fill this boiler in ten hours.

The circulation of the water is up the front tubes and down the rear. The tube area is made equal in both sets of tubes in order to provide free circulation both for water and steam. Steam pockets cannot form and the arrangement equalizes heating throughout the boiler.

The blow-off is located at the very lowest point of the bottom of the mud drum. Feed water is usually introduced into the steam drum directly into the down-take tubes far below the water line.

The furnace is of the external oven type, the grate surface being entirely surrounded by highly heated surface in order to avoid chilling the products of combustion. Any type of stoker may be applied to the furnace.

The gases in their flow from furnace to outlet are compelled to sweep over heating surface in every foot of their travel; every foot of heating surface in the boiler is swept over by the gases in their travel. The gases are closely enough confined to the heating surface to entirely surround and cover it, as well as establish a strong scrubbing action of gas to metal. No chance for gases to short-circuit exists. No chance for gases to enter pockets in the setting unfilled with heating surface exists. A very long gas travel is provided. The design provides for the very best heat transfer by conduction and convection.

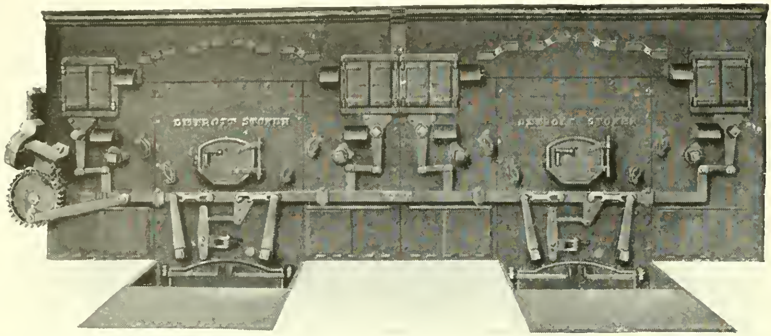
The tubes being vertical, soot and dust carried on gases and impurities precipitated from the water fall to the mud drum, where easy removal is provided for.

The boiler is constructed of the very best homogeneous steel, made by the open hearth process. The highest character of workmanship known to the art at the present day is put upon these boilers. The closest scrutiny and inspection by the best informed on this workmanship is invited and requested.

DETROIT STOKER COMPANY

DETROIT, MICH.

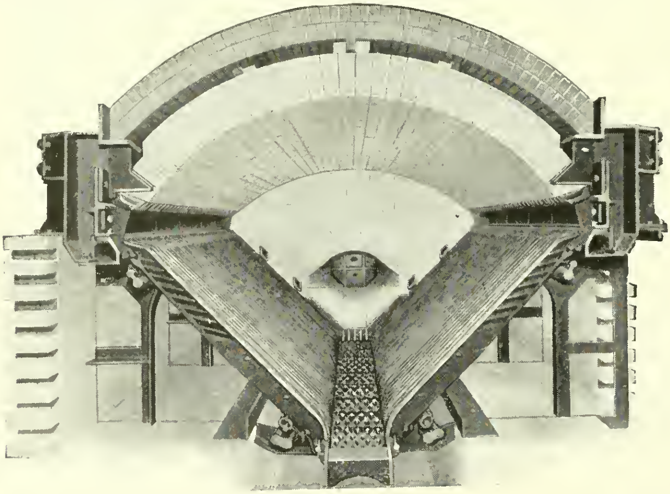
THE DETROIT STOKER



Front view of two stokers in one battery to be operated by either a fully enclosed, adjustable speed, double engine or electric motor, as preferred.

Either stoker may be operated by hand when desired.

The openings through the front admit air for combustion. The even distribution of fuel on the grates insures high overload and good efficiency.



Rear view showing the double arch construction used when the stokers are installed with the extension setting. Air admitted through the front, under control, is heated between the arches and enters through openings directly over the coking coal as it is fed from the coal magazines at the upper end of the grates on both sides.

Each alternate grate is operated by links connected to the operating bar in front and have a slicing motion to keep the entire bed of fire moving towards the center of the furnace. The movement of the vibrating grates prevents the clinkers from forming on the grates.

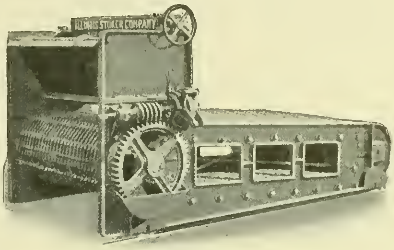
The clinker crushers at the bottom, having a continuous motion, grind the clinkers and deposit the refuse in the ashpit below.

ILLINOIS STOKER COMPANY

ALTON, ILLINOIS, U. S. A.

MANUFACTURERS OF CHAIN GRATE STOKERS

THE ILLINOIS STOKER COMPANY'S GRATE STOKER



Showing driving mechanism of Stoker

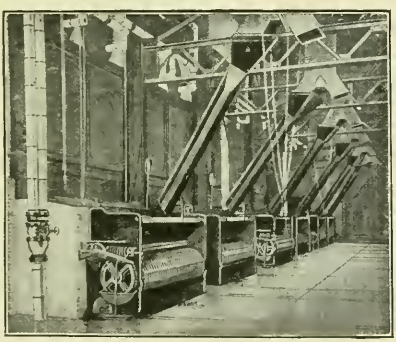
The general view of this Stoker is given in the illustration herewith. The coal is supplied to the traveling grate from the hopper, shown in the upper front part of the furnace. The grate in carrying the coal into the furnace passes under an adjustable gate which can be raised to give any desired thickness of fuel bed up to twelve inches by turning the hand wheel at the top of the Stoker. The adjustment, together with the variable speed at which it is possible to operate the grate by means of the speed adjusting lever shown on the driving mechanism, makes it possible to feed any desired number of pounds of coal per square feet of grate surface per hour into the furnace.

By controlling the thickness of the fuel bed and speed with which the coal is fed into the furnace, it is possible to obtain any desired load from the boiler with coal of either very high or very low heat value, or coal very small or coarse in size.

By raising or lowering the gate and determining the thickness of the fuel bed, which is fed into the furnace, proper allowance can be made for the burning of coal of various sizes. For example: Assuming that the draft over the fire is constant, the larger size of coal will have larger air spaces between the individual pieces of coal than a coal of smaller size, so that with a given draft more air will be forced through a coal bed six inches thick while burning the larger size of coal than will be forced through the same thickness while using coal of a smaller size. Adjustment should therefore be made in each case so as to obtain the proper amount of air through the coal for the proper burning of the particular kind of coal used.

The ease with which the gate can be lowered or raised in the Illinois Stoker makes it feasible to maintain the proper thickness of the fuel bed for each kind of coal supplied to the furnace. The exact thickness of the fuel bed is at all times indicated in inches by the gauge shown just above the handle for raising the gate.

Attention is called to the solid construction of the side frame of this Stoker, which is cast in one single piece from the front to the rear of the Stoker, so that the entire chain and driving mechanism is supported on this single solid casting. This construction is found only in the Illinois Stoker and makes it the most rigid and substantial Stoker on the market. Note the heavy ribs on all edges of the side frame.



Illinois Stokers in operation

GOOD FEATURES OF ILLINOIS STOKER

Heavy Castings throughout and Rigid Bracing. Sprockets engage on Rollers, not on rods. Evenness of chain due to close spacing of rollers. Uniform distribution of air supply through coal. Patented air baffling system in rear of grate. Large combustion space due to nclined grate. Excellent speed controls. Short Link. Minimum loss of coal through grate. Independent flat ignition arch. General appearance and mechanical design. Drums are used on the rear end instead of sprockets, hence there are no rear sprockets to cause trouble.

Complete illustrated catalogue mailed on request.

GREEN ENGINEERING CO.

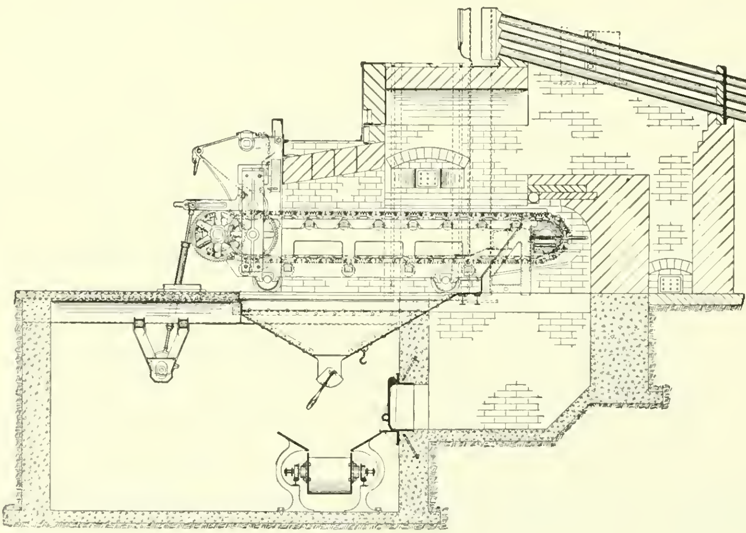
CHICAGO ILLINOIS

MANUFACTURERS OF GREEN CHAIN GRATE STOKERS; GECO RATCHET ASH DRAGS; GECO PRESSURE WATERBACKS; GECO PNEUMATIC ASH HANDLING SYSTEMS.

GREEN CHAIN GRATE STOKER

The Green Chain Grate Stoker gives in service a practical demonstration of progressive combustion, the fuel being fed in at the front of the furnace and carried at regulated speed to the rear of the furnace, where, as ashes, it drops into the ash pit to be removed mechanically or by hand. Operation is entirely automatic and continuous. The fuel is ignited and coked at the front end of furnace, air is admitted through automatically cleaned air spaces in grate, and smokeless combustion with low grade fuel is produced. It will quickly pick up or drop a heavy load or economically bank the fire. Labor cost for cleaning furnace is low and the cost for repairs minimized.

Green Stoker Applied to a Horizontal Water Tube Boiler

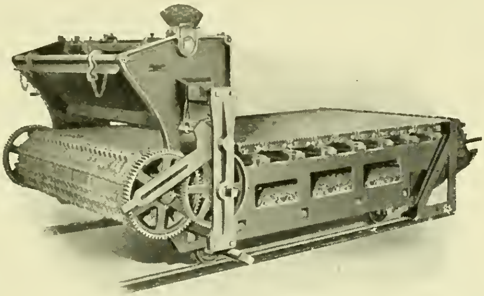


Construction

Two types of grates are made adaptable to any make of boiler. The fire bed may be level or sloping. The side girders of frame are entirely away from the fire and arranged to provide an increased air supply. Heavy cast-iron links, thoroughly ventilated, form the firing bed. These links interlock and automatically clear the air spaces without excessive loss of fine coal. The rear cross girder is fitted with a heavy plate on under side upon which ashes accumulate and, in connection with the members just above and below, prevent the passage of air around rear portion of grate, where ashes discharge; and this is further supplemented by dampers, which prevent the leakage of air past the side frames or below the lower part of the chain.

GREEN CHAIN GRATE STOKER

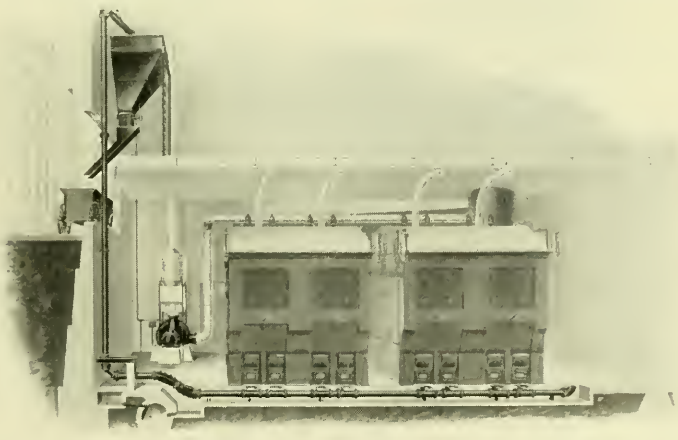
The grates are built in any width and in lengths from 9 ft. up to 12 ft. deep. Driving mechanism consists of ratchet, cast-steel pawls and cast-steel spur gear train babbitted in a special self-contained frame independent of, but bolted to the stoker front side frame. Quick adjustment may be had over a wide range and the source of power may be either above or below the boiler-room floor. A regulating feed-gate permits hard firing and is provided with an easily renewable tile lining, which prevents injury to the gate by fire eating back into coal hopper. The igniting arch is adaptable to any width furnace and easily renewable at low cost. It is flat, ventilated, and it gives uniform ignition the full width of the furnace and allows local repairs at any point without undue loss of use of the boiler.



Stoker Withdrawn From Setting

GECO PNEUMATIC ASH HANDLING SYSTEM

This system consists of a conveyor pipe located convenient to ash pits and provided with openings into which ashes are readily hoed. An air current of high velocity instantly carries the ashes to a separator and storage tank. On entering tank the ashes are automatically sprayed, thoroughly quenched, separated from air and deposited. An exhauster produces the air current. Tank may be readily emptied by gravity into carts, or cars. One man operates system.



MURPHY IRON WORKS

DETROIT, MICHIGAN

FOUNDED 1878

MANUFACTURERS OF THE MURPHY AUTOMATIC SMOKELESS FURNACE

THE MURPHY AUTOMATIC FURNACE is automatic in all its functions. It feeds and distributes the coal and removes the ash and refuse.

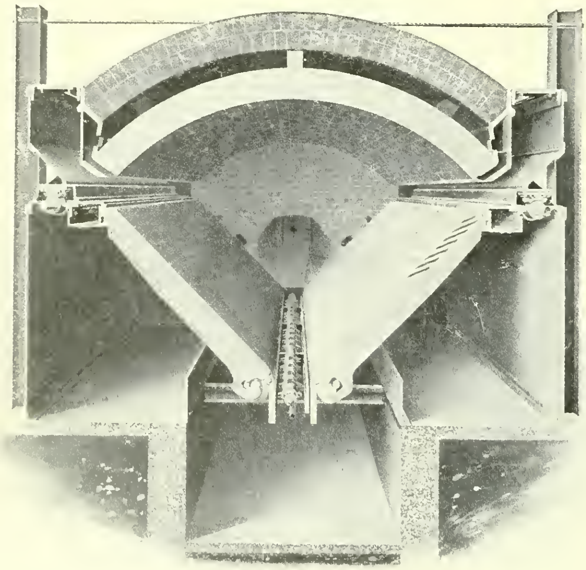
It is adaptable to any type of boiler and to units of any size.

It will handle economically all grades of bituminous fuels and is practically smokeless under normal operating conditions.

It is capable of handling variable loads and heavy overloads efficiently and with minimum attention.

The cost of maintenance is low, averaging about 10c. per horsepower per year.

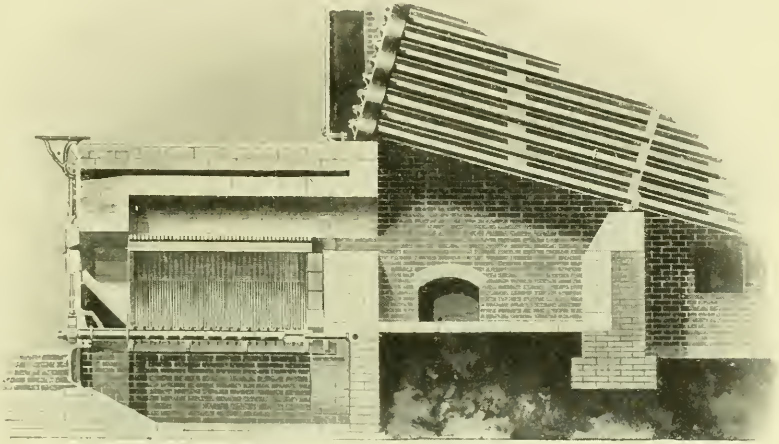
It operates with natural draft, the cost of actuation approximates $\frac{3}{4}$ of 1 per cent of total steam generated.



The Murphy Automatic Smokeless Furnace
REAR VIEW

Its usefulness is not limited to steam making, it will give excellent results in all operations where high temperatures are required, such as brick drying, cement burning, salt evaporation, calcining of soda ash, heating furnaces, etc.

MURPHY IRON WORKS



Murphy Furnace—Dutch Oven Setting

At either side of the furnace extending from front to rear is the coal magazine into which the coal may be introduced either by hand or mechanically. At the bottom of this magazine is the coking plate against which the inclined grates rest at their upper ends. The stoker boxes, operated by segment gear shafts and racks, push the coal over the coking plate and onto the grates. The grates are made in pairs, one fixed and the other movable. The stationary grates, at their lower ends, rest on the grate bearer, which also acts as a support for the clinker grinder. The clinker grinder consists of a square steel shaft, onto which is slipped small cast iron toothed segments, which are readily replaced in case of breakage. Just over the coking plate is the arch plate, from which a fire brick arch is sprung over the entire furnace. Upon this arch plate are cast numerous ribs to form a series of air ducts immediately over the coking plate, conveying the heated air from the chamber above the arch into the combustion chamber. This arch plate also forms the wall of the magazine. The furnace, or battery of furnaces, can be operated by a small automatic engine, motor or by overhead shaft and ratchet drive, as may be desired. Arrangement is made for exhaust steam connections at the lower end of the grates for the protection of this portion of the grates and clinker grinders and for the softening of the clinker. In connection with horizontal tubular boilers or water tube boilers horizontally baffled, the Murphy furnace can be installed with a flush front setting. Arrangement can be made for extended or Dutch oven settings, should this be desired.

LACLEDE-CHRISTY CLAY PRODUCTS CO.

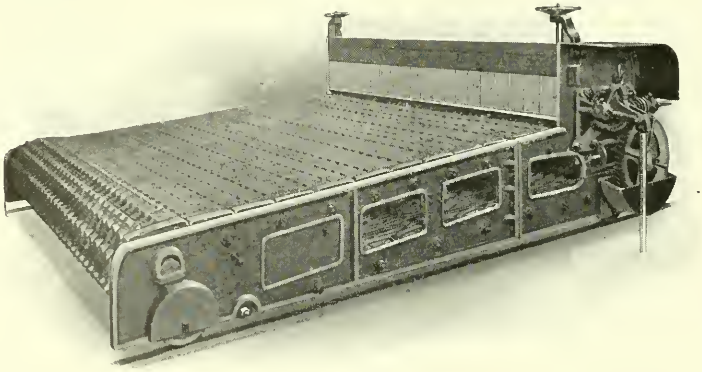
ST. LOUIS, MISSOURI

"LACLEDE-CHRISTY" CHAIN GRATE STOKERS; CLAY PRODUCTS AND REFRACTORIES; INDUSTRIAL PLANT CONSTRUCTION.

CHAIN GRATE STOKER

The "Laclede-Christy" Chain Grate consists of an automatic, traveling, self-cleaning endless chain of narrow links all of the same design, supported on a strong rigid frame and operated by a simple driving device.

By means of a hopper and an adjustable feed gate, the coal is spread evenly across the width of the grate and carried under the patent ignition arch where the volatile gases are driven off and consumed. The remaining coke is consumed toward the back of the grate and the ashes discharged into the ash pit at the rear end of grate.



The frame work which supports the chain consists of heavy cast-iron sides tied together with rods and pipe spreaders and held rigid by a structural iron diagonal brace. Pipe rollers are provided to support the chain and the complete grate is mounted on four flanged wheels to fit tee rails. By this construction the stoker can be removed quickly from under the boiler for repairing the furnace.

Driving mechanism consists of a worm gear operated by a pawl and a ratchet wheel, driven by an eccentric fastened to a shaft either overhead or underneath. Speed may be closely regulated and in case of accident to the engine or motor the grate may be operated by hand.

SPECIAL FEATURES

Evaporation is produced at a minimum cost for fuel and labor.
Boiler can be forced without losing economy.
It will burn any kind of bituminous coal without smoke.
It is self-feeding, self-cleaning and labor saving.
During operation it may be quickly adjusted.
Sprockets engage rollers instead of links.
It does not injure boilers or accessories.
Any fireman can make repairs should they become necessary.
Design permits of large combustion chamber.
Incline of grate permits of installation where headroom is limited.

ST. JOHN GRATE BAR CO.

A. B. Willoughby, Manager

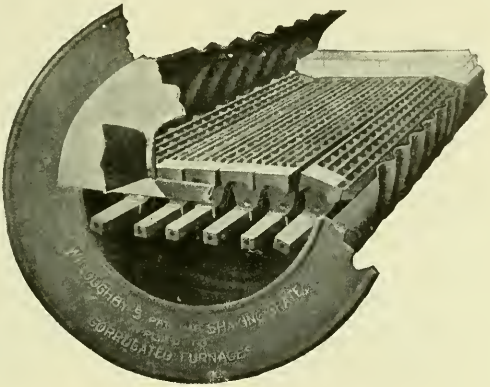
MACHINERY DEPT. THE BOURSE, PHILA. PA.

CONSULTING AND MECHANICAL ENGINEERS, EXPERTS IN COMBUSTION.

MANUFACTURERS OF WILLOUGHBY'S PATENT IMPROVED SHAKING GRATES AND FURNACES, WILLOUGHBY'S PATENT ALTERNATING SHAKING GRATES FOR FIRE ENGINES AND ALL BOILERS WITH CIRCULAR FIRE BOXES.

WILLOUGHBY'S ST. JOHN PATENT IMPROVED SHAKING GRATES AND FURNACES

These grates are especially suitable for internally fired Corrugated Furnaces, **but are used to advantage in all kinds of boilers and furnaces,** with any fuel, and with natural, forced or induced draft.



FIRES CLEANED BY SHAKING

Their use does away very largely with the need of "cleaning fires," since the construction and operation is such that all refuse can be broken up and passed through the bars by shaking. These grates have been run seven weeks without cleaning, using Pittsburgh coal in internally fired boilers.

INCREASED BOILER CAPACITY

The air space of these grates is so much greater than that of other types that much more coal can be burned per foot of grate surface, thereby evaporating more water and increasing the capacity of the boiler. It is also possible to burn inferior coal with good results, and less clinker than with other grates.

CONSTRUCTIONAL FEATURES

These grates run longitudinally, and present a flat surface to fire upon, over which a slice bar or hoe may be used without catching. This is a very advantageous feature not found in other shaking grates.

SUMMARY OF ADVANTAGES

The most business-like grate on the market, absolutely "*fool proof.*"
It is simple in construction. Easily operated.
It will reduce your coal bills. Adapted to any style furnace.
No cold air over the fire.
Adapted to either hard or soft coal.
Will reduce the clinker to a minimum.
Increased air space. Will improve the efficiency of your boiler.
Cleanings are reduced to a minimum, and doors kept closed longer than with any other method.
No bolts or nuts or cotter pins to become loose or broken and drop out, thus disabling grate at the most inopportune times.

GUARANTEE

With the installation of the WILLOUGHBY PATENT IMPROVED SHAKING GRATES, we will guarantee the ability to develop twenty-five per cent higher capacity than can be secured from flat stationary grates under like conditions, or, we will guarantee the ability to develop the same capacity as you now secure (from flat grates) on at least ten per cent less fuel under like conditions on a twenty-four hour (or longer) run. Provided: an evaporation test be made with both flat grates and this grate in the presence of our representative.

CATALOG ON REQUEST

AMERICAN BLOWER COMPANY

DETROIT, MICH.

MANUFACTURERS OF HEATING, VENTILATING, DRYING, MECHANICAL DRAFT AND BLAST EQUIPMENT; VERTICAL SELF-OILING STEAM ENGINES; STEAM TRAPS; FANS AND BLOWERS FOR ALL PURPOSES.

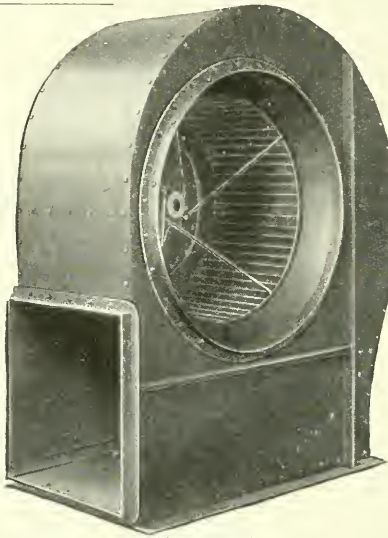
"SIROCCO" FANS and BLOWERS
(The Original Turbine Type)

DISTINGUISHING FEATURES

"Sirocco" Fans have a large intake chamber practically unobstructed by the projection into it of blades or other parts, and employ blades which are short radially and very long axially.

COMPARATIVE CAPACITY

Some idea of the great capacity of the "Sirocco" Wheels may be gained by a comparison of two wheels of equal diameter and speeds. The "Sirocco" will discharge 3¼ times more air and produce 5¼ times more pressure than an ordinary steel plate fan will; or delivering equal volumes against equal resistances, the "Sirocco" Fan Wheel will be 16% smaller, run at 72% of the speed and require 20% less power; or for the same horse-power input to each fan, the "Sirocco" will deliver 25% more air at 70% of the speed; or with housings of the same height the "Sirocco" Fan has 35% greater capacity at 65% of the speed.



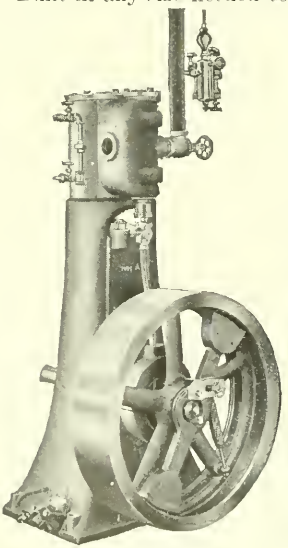
"Sirocco Fan"

GENERAL

In the "Sirocco" Fan are combined conservation of space, speed and power in a way never before equalled in a fan of any other type.

Built in any size needed to meet given conditions.

Complete description, capacity tables, etc., in Bulletin No. 284.



Type A Engine

VERTICAL SELF-OILING STEAM ENGINES

Type A—Single Cylinder
" E—Double "

DISTINGUISHING FEATURES

These engines will run from three months to two years without requiring adjustment or the addition of oil to the original supply. These long runs without attention are made possible by the patented oiling system. Every frictional surface *is running on oil*; there is no contact between metals, which eliminates wear.

ADAPTABILITY

Unexcelled as a motive power for any duty within their capacity. These engines have no equal for driving electric generators, exciters, centrifugal and all types of power pumps, paper machines, centrifugal dryers, etc.

CAPACITY

Up to and including 120 horse-power.

Complete descriptive matter, specifications, etc., in Bulletin No. 334.

AMERICAN BLOWER COMPANY

"DETROIT" STEAM TRAPS

The only successful modifications in tilting traps made in years have been embodied in the "Detroit."

The "Detroit" Traps are the simplest possible mechanism for automatically holding steam in check and delivering water. They are applicable anywhere that steam is used, for whatever purpose, and can be used for draining any system on which a pot, float or bucket trap is now or would be used.

All working parts are on the outside, in plain sight, and easily accessible. The tilting of the tank indicates at all times the successful operation of the trap. There is no ball or float inside the receiver and nothing to leak, collapse, rust, corrode, or stick. The valve seats and discs are renewable.

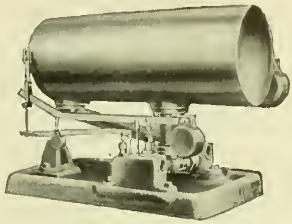
The Return Trap takes condensation from whatever source and delivers it to the boiler at practically the temperature at which it is condensed.

The Non-Return or Separating Traps are perfectly adapted to draining oil and steam separators; bleeding high or low pressure headers; draining receivers between high and low-pressure cylinders in compound engine installations, etc.; in fact, any service within their capacity in rubber plants, paper mills, power plants, heating, drying and cooking apparatus, vacuum pans and triple effects in salt works, sugar refineries, etc.

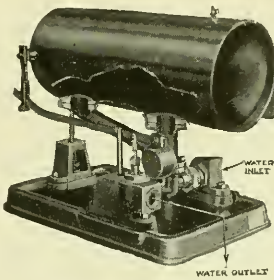
Condensation can be most successfully removed from any apparatus or system working under a vacuum by *"Detroit" Vacuum Traps*.

Live steam or compressed air is employed for discharging the trap or elevating the contents to any desired height within the limit of the pressure admitted to the steam valve.

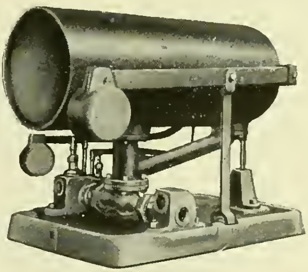
In construction the "Detroit" Vacuum Trap is a modification of the "Detroit" Return Trap.



"Detroit" Automatic Return Steam Trap



"Detroit" Separating Trap



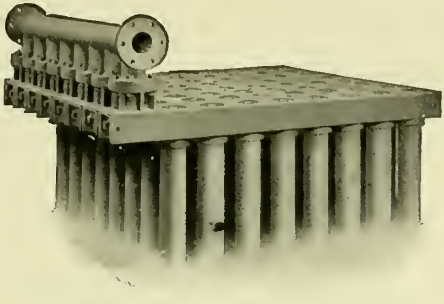
"Detroit" Vacuum Trap

"DETROIT" RETURN OR VACUUM TRAPS

CAPACITY

Size Trap	Water Inlet and Outlet	Size Steam Inlet	Pounds Per Hour	Square Feet Direct Radiation	Lineal Feet 1-Inch Pipe Direct Radiation	Approximate Shipping Weight lb.	Telegraphic Code Word Return Trap
10	¾"	½"	830	2800	8400	275	Dabbler
11	1	¾"	1500	5000	15000	325	Dabble
12	1¼	1	2500	8300	25000	425	Dabster
13	1½	1¼	5000	16500	50000	500	Dacapo
14	2	1½	6600	22000	66000	700	Dactyl
15	2½	2	15000	50000	150000	900	Daddock
16	3	2	24000	80000	240000	1000	Dagger

Capacities are based on average direct radiating conditions.
For capacities Separating Traps, ask for Curve Sheets Nos. 237–A and 238–A.
Complete description in Catalogue No. 326.



Group of Green's Fuel Economizer Sections, Showing the New Extended Top Header with Flexible Connection to Branch Pipe

DIMENSIONS

Height from bottom of sections to top of scraper gearing is 13 ft. $5\frac{1}{4}$ inches. These dimensions are based on 9 ft. pipes; 10 ft. and other lengths are provided. Height over headers 10 ft. $2\frac{1}{2}$ inches. Space occupied by one section, $7\frac{1}{4}$ inches.

Widths: Four pipe sections: 3 ft. 4 ins. inside walls without side dampers, 4 ft. 1 in. with one damper, 4 ft. 10 ins. with two; areas between pipes, 16.6, 23.85 and 31.10 square feet respectively.

Six pipe sections: 4 ft. 8 ins. inside walls without side dampers, 5 ft. 5 ins. with one damper, 6 ft. 2 ins. with two; areas between pipes, 21.85, 29.10 and 36.35 square feet respectively.

Eight pipe sections: 6 ft. inside walls without side dampers, 6 ft. 9 ins. with one damper, 7 ft. 6 ins. with two; areas between pipes, 27.00, 34.25 and 41.5 square feet respectively.

Ten pipe sections: 7 ft. 4 ins. inside walls without side dampers, 8 ft. 1 in. with one damper, 8 ft. 10 ins. with two; areas between pipes, 32.25, 39.50 and 46.75 square feet respectively.

Twelve pipe sections: 8 ft. 8 ins. inside walls without side dampers, 9 ft. 6 ins. with one damper, 10 ft. 3 ins. with two; areas between pipes, 39.25, 44.75 and 51.50 square feet respectively.

Green's Junior Economizer in special sizes for narrow spaces.

The pipes are of a special grade of iron, cast in vertical dry sand molds and tested to 500 lb. pressure per square inch before forming into sections; 350 lb. after forming, and twice the working pressure when installed.

The connections between the top and bottom headers and the branch pipes are entirely outside the economizer chamber and are easily made and unmade by the ordinary mechanic. They have sufficient flexibility to take care of unequal expansion due to changes of temperature and distortion due to slight unequal settlement of foundations.

The top headers are planed on the sides, making a gas-tight joint which renders other covering unnecessary. Our Ovoid Bottom Header is specially designed to permit the soot to fall through. Access to every part of the economizer is easily accomplished by means of Green's Sectional Covering.

Green's Economizer is arranged to secure the greatest heat absorption while impeding the draft the least.

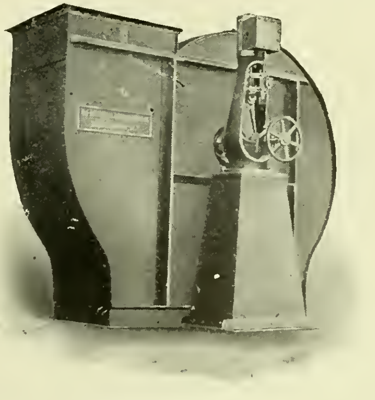
Green's Economizer has been perfected by 60 years' use.

Green's Economizers are used in the largest and most economical steam plants throughout the world. Many have been in service for more than 30 years continuously.

GREEN'S STEEL PLATE FANS for heating and ventilating, mechanical draft, conveying materials, etc.

Wheels and housings are extra heavy. Wheels have angle iron fastenings for the floats and are strengthened by angle iron rings in the larger sizes.

The wheels are corrected for running balance, and bearings are ring-oiled and adjustable.



Engine Driven Fan

Send for special publications on (1) Fuel Economizers, (2) Fans and Blowers, (3) Heating and Ventilating Buildings, (4) Mechanical Draft, (5) Drying, (6) Waste Heat Air Heaters, (7) Planing Mill Exhausters, (8) Heat Saving in Water Gas Plants, Breweries, Cement Mills, Paper Mills, etc.

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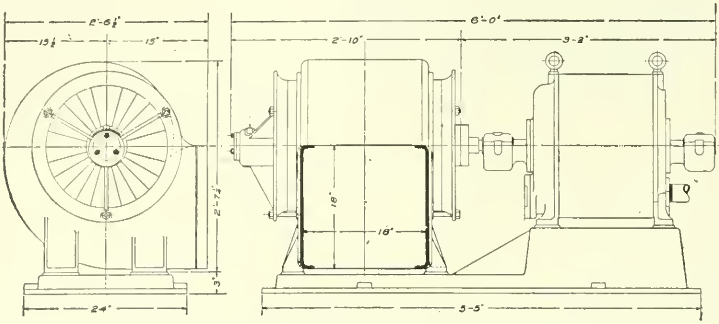
McEWEN BROS.

WELLSVILLE, N. Y.

CENTRIFUGAL PUMPS, BLOWERS, BOILERS, FLEXIBLE COUPLINGS



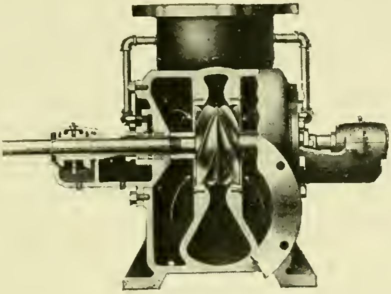
BLOWERS FOR FORCED DRAFT

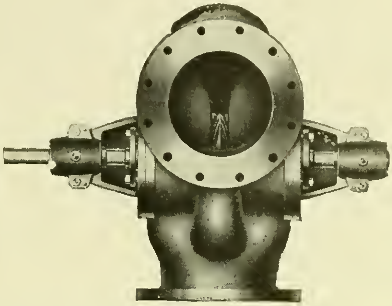
To develop the maximum capacity of a boiler plant mechanical draft is necessary. Chimneys cannot produce draft enough; and where the underfeed or retort types of stokers are used, forced draft is indispensable. Steam turbine driven forced draft blower units are ideal. The turbine runs perfectly on the throttle or under pressure and air control. The exhaust from the turbine is clean and may be used for feed water heating without danger to boilers or the cost of using and removing cylinder oil. But for highest economy the blower must run at turbine speeds. For instance, a small steam turbine develops 15 brake horsepower at 1000 r.p.m. and 40 brake horsepower at 3500 r.p.m., with the same pressure and total steam per hour. A larger turbine of another type develops 80 brake horsepower at 600 r.p.m. and 160 horsepower at 1600 r.p.m. with the same pressure and total steam per hour. The best blower for forced draft service is the one which runs as well as the turbine and at its best speed.

Size	Outlet	Weight	Space Required,			Total Air Pressure, 1–4″ w.g.		Total Air Pressure, 4–8″ w.g.	
			Length	Width	Height	Capacity, c.f.m.	Speed, r.p.m.	Capacity, c.f.m.	Speed, r.p.m.
18″	18x18	400	34	29	31	6200–12400	1870–3740	9400–13350	2830–4000
24″	24x24	700	40	39	42	11000–22000	1400–2800	16700–23500	2120–3000
30″	30x30	1150	46	49	52	17300–34600	1120–2240	26200–37200	1700–2400
36″	36x36	1700	54	60	63	25000–50000	940–1880	37700–53500	1410–2000
42″	42x42	2300	60	70	73	34000–68000	800–1600	51300–72800	1210–1700
48″	48x48	3000	66	80	84	44000–88000	700–1400	66800–95000	1060–1500

CASING.—Cast-iron sides with sheet steel volute. BEARINGS.—Babbitt lined, ring oiling, dust proof, oil proof. ROTOR.—Increase pitch propellers with central deflector, on nickel steel shaft. Stays in balance. Removable endwise. PAINTING.—Filled and painted inside and out with oil and acid proof flat finish machine enamel. RATING.—Capacity stated for maximum efficiency at required pressure. Economic range from 25% below to 25% above rating with efficiency above 90% of maximum. GUARANTEE.—Best material and workmanship and rated capacity. Faulty parts failing within a year of shipment replaced by duplicates f.o.b. works on request.

McEWEN BROS.





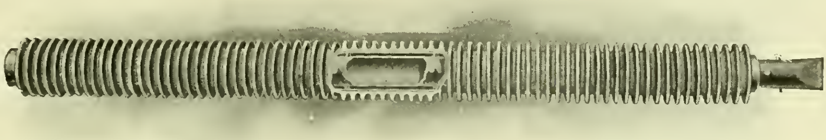
HIGH SPEED CENTRIFUGAL PUMPS

The cuts above illustrate the type of high-speed centrifugal pump designed especially for steam turbine drive on condenser and hot well service in power plants and for other service where large volume at low head and high speed is desired with better unit economy or lower operating cost. High suction lift possible.

Size	G.p.m.	Head	R.p.m.	Pipe Vel.	Floor Space	Weight
8″	800–2000	5– 50′	1200–4000	7–13′	24″x 38″	900 lb.
10″	1800–3000	5– 50′	1000–3200	7–13′	28″x 42″	1200 lb.
12″	2500–4500	5– 50′	900–2700	7–13′	44″x 44″	1600 lb.
16″	3600–7500	10– 80′	1000–3000	7–13′	44″x 58″	2200 lb.
20″	6000–12000	10– 80′	900–2600	7–13′	53″x 67″	3300 lb.
24″	9000–18000	10–100′	700–2300	7–13′	63″x 78″	4500 lb.
30″	15000–30000	15–100′	700–1800	7-13′	75″x 85″	7000 lb.

CASING.—Close grained, sound cast-iron, with volute suction and discharge. Removable bronze throat. BEARINGS.—Split shells lined with best babbitt, or made entirely of lead bronze if preferred. Laminated oil rings. Bearings removable without disturbing shaft. ROTOR.—Helical type bronze impeller on nickel steel shaft, bronze covered where exposed to water. Removable endwise from casing. STUFFING BOX.—Best hydraulic packing, water sealed. Bronze gland recessed to prevent slinging water. COUPLING.—Flexible type, all steel with reservoir lubrication. PAINTING.—Filled and painted with oil and acid proof, flat finish, steel color machine enamel. GUARANTEE.—Best efforts made to fit the pump to its work. Material and workmanship best for the purpose. Parts failing from defect within one year from shipment renewable by duplicate f.o.b. works. RATING.—Pumps rated at highest efficiency for required head and speed. Economical range, 25% below to 25% above rated capacity.

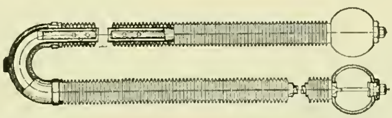
The elements consist of bodies of seamless cold-drawn steel tubing, to the outside of which is snugly fitted a heat-resisting cast-iron covering with deep external annular corrugations for the protection of the bodies against the action of the heated gases. These annular gill flanges form an extension surface for the absorption of heat from the hot gases, which heat is passed to the steam contained in the tubes. They provide a section of great ultimate strength with absolute freedom from internal strains. They also provide a mass of metal which acts as a reservoir for heat to be imparted to the steam regularly and prevent fluctuations in the temperatures of the hot gases from producing corresponding fluctuations in the superheating of the steam. An inner tube or core is fitted to each straight heating tube, the core being of cylindrical form closed at each end and supported concentrically with the tube by frequently spaced steel knobs. This thin annular conduit for passage of the steam, while receiving the superheat, adds to the efficiency of the heating surface, insures complete distribution of steam through all parts of superheater and the impossibility of passing water through the elements.



SUPERHEATED STEAM

Superheating steam has become a modern necessity; saving fuel, increasing capacity and duty of engines and turbines, insuring longer life and greater economies in boiler, steam pipe and condenser.

For steam turbines, reciprocating engines, generating units, feed pumps and auxiliaries, any superheat up to 500 deg. Fahr. will be found satisfactory. For industrial uses, temperatures up to 1200 deg. Fahr. are made possible by the Foster construction.



Cross section of return bend element and connecting headers used in the construction of Foster Superheaters

DUVAL METALLIC PACKING

is extensively used for superheated and saturated steam, also for steel or iron plungers where working in water or oil, in pumps or accumulators, for heavy pressures from 500 to 2500 pounds per square inch of pressure. No special stuffing-box is required. The packing is flexible, made of fine quality wire plaited in square form and is easily cut with wood chisel. It is adopted in the French, British and American Navies.

SUPERHEATED STEAM BRONZE GASKETS

give excellent satisfaction for flanged joints carrying superheated steam. The metal has elastic properties and the corrugations are even, with sharp ridges.

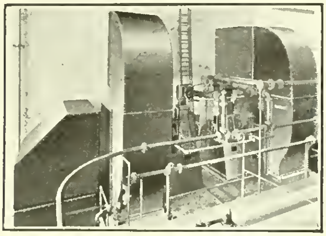
B. F. STURTEVANT COMPANY

HYDE PARK, MASS.

Offices in Larger Cities

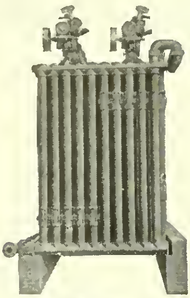
MECHANICAL DRAFT, FUEL ECONOMIZERS, STEAM TURBINES, STEAM ENGINES, GASOLENE ENGINES, GASOLENE ENGINE GENERATING SETS, MOTORS, GENERATORS, STEAM TRAPS, HEATING AND VENTILATING SYSTEMS, FANS, BLOWERS, EXHAUSTERS, ETC.

MECHANICAL DRAFT



Draft produced by a fan is called mechanical draft, and may be forced or induced as conditions demand. Its cost is from 20 to 40 per cent of that of a chimney. Its intensity permits of the burning of finely divided or low grade fuel. It makes possible the utilization of the flue gases which a chimney wastes in producing draft, it is independent of the weather, decreases smoke, increases the capacity of an existing plant, and serves as an auxiliary to a chimney already overburdened. It saves space and is portable.

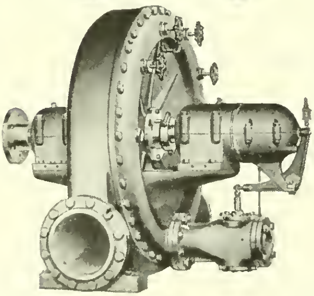
FUEL ECONOMIZERS



The Sturtevant Economizer effects:
A saving of 10 to 20 per cent in fuel,
An increase of 20 to 40 per cent in boiler capacity,
An appreciable extension of the life of a boiler,
A purification of the feed water,
A reduction in expense of repairs,
The deposit of large amounts of soot.

In the Sturtevant Economizer the pipes are arranged "staggered" instead of in straight rows, thereby giving the pipes a better opportunity to absorb heat from the gases. These economizers are made with taper metal-to-metal joints that require no packing, cement or rusting. The placing of the pipes of one row opposite the spaces of the adjacent sections increases the effective area of the transmitting surfaces and thoroughly breaks up the currents of hot gases by directing them between the pipes and against those standing in their paths.

STEAM TURBINES

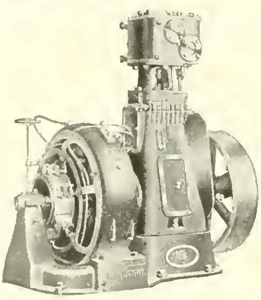


The Sturtevant Steam Turbine is of the multi-velocity type, and its operation is such as to give high efficiency, and permit of moderate rotative speeds without gears. Hand valves are used for shutting off the nozzles, and the speed is regulated by a centrifugal throttling governor placed on the end of the shaft.

No special foundations are required and the turbine can be placed on an ordinary floor. Internal lubrication is unnecessary, therefore the exhaust steam is free from oil.

5 regular sizes from 5 to 250 H.P.
Approximate speed from 4000 to 1000 R.P.M.

STEAM ENGINES
(Automatic High Speed)



Vertical Single Cylinder from 5 to 87 H.P.
Vertical Compound from 35 to 171 H.P.
Horizontal Center Crank Engine from 39 to 225 H.P.

Sturtevant Engines are adapted to continuous operation for long periods without attention. Gravity lubrication and complete enclosure of moving parts insure cleanliness and high mechanical efficiency. Rites Governor gives 1½ per cent speed variation only.

MOTORS, GENERATORS AND GENERATOR SETS
Direct Current Apparatus for any Standard Voltage

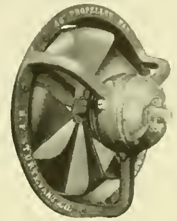
Bi-Pole Motors (enclosed and semi-enclosed type)	¼	to 3 H. P.
Four-Pole Motors	2	to 30 H. P.
Eight-Pole Motors	1	to 225 H. P.
Six-Pole Generators	5	to 17½ K. W.
Eight-Pole Generators	20	to 150 K. W.
Turbine Generating Sets	3	to 50 K. W.
Steam-Engine Generating Sets	5	to 150 K. W.

B. F. STURTEVANT COMPANY

STEAM TRAPS

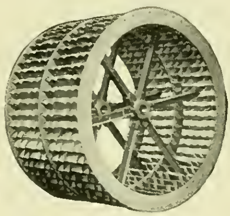
This steam trap, made for different pressures, is designed for steam heaters or radiators of any construction. Both extension and cone are of brass ground to a fit. The pot is readily removed for cleaning by loosening up the bolts.

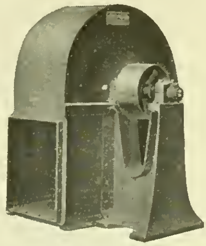
PROPELLER FANS



Propeller fans are designed for use against low pressures, and are applicable for ventilation and exhauster work in boiler and engine rooms, kitchens, clubrooms, smoking rooms, offices, stores and similar places. They are constructed with a frame of cast iron, that is fastened into the wall of the building and are driven by either belt or direct-connected electric motors that are enclosed and dust-proof. The construction of these propeller fans is exceptionally strong and durable. Propeller fans are made in sizes of from 18 to 120 inches in diameter.

MULTIVANE FANS





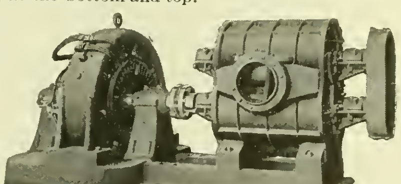
Multivane blowers and exhausters driven by direct-connected Sturtevant motors, turbines, and engines form the most satisfactory and efficient fan sets on the market. The blast wheel or runner for this fan is composed of shallow floats, which permit the use of very large inlets while maintaining the necessary blade area. The large inlet allows the air to enter with the least loss in friction. Each blade or float is spooned to distribute equally the pressure within the casing and to add rigidity and strength to the wheel.

STEEL PLATE FANS

Sturtevant steel plate fans are designed for all sorts of blower and exhauster work. They are the result of fifty years' experience in blower design, are especially strong and durable and are suitable for direct-connected steam engine and electric motor drive and for belt drive. Steel plate fans are built for ventilation and mechanical draft installations, and for planing mill and other exhauster work.

BLOWERS AND EXHAUSTERS

The Sturtevant High Pressure Blower is made in two types; in the smaller sizes the idler is directly above the impeller, and the shafts lie in a vertical plane. In the larger sizes, the shafts are in a horizontal plane, the intake and discharge being at the bottom and top.



High Pressure Blowers are designed to deliver air at pressures up to five pounds. They are especially adapted to furnishing blast for cupolas, gas and oil burners, annealing and smelting furnaces, cement kilns, and for all sorts of blower or exhauster work demanding high pressures. Special stuffing-boxes to prevent leakage are furnished when these blowers are used to handle gases.

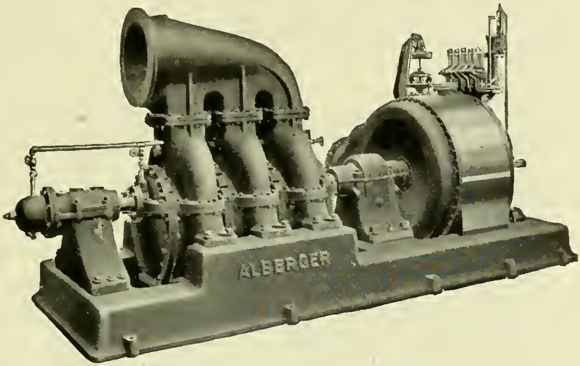
The B. F. Sturtevant Company makes complete installations, including direct-connected, belted, or geared engine or motor, exhauster, automatic regulator, blast gates, by-pass connections, and valves.

STURTEVANT HEATERS

The Sturtevant fan system of heating and ventilating is economical and positive, heated air providing ventilation as well as heat. Indirect hot blast coils are built of one inch extra heavy steel pipe screwed into cast iron sectional heater bases. Entire heater is enclosed in steel plate casing. Heater is applicable to use of either live or exhaust steam or hot water. System can be used for heating and ventilating any sort of building. The operation is independent of the weather or of atmospheric conditions. The air may be washed, dried, moistened or cooled, as well as heated. Hot air from the heater is forced by a fan through ducts into the building to be heated, and is allowed to escape through vent flues. Fans are driven by steam engine, motor or belt. The steam engine exhaust is used in the heater, thus eliminating the expense of running the engine. Temperature of air entering each room may be closely regulated by thermostatic control.

THE ALBERGER COMPANIES

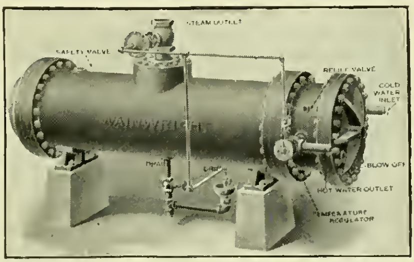
ALBERGER PUMPS AND STEAM TURBINES



Alberger Curtis Pumping Engine.
Multi-Impeller Turbine Type.
Patents applied for.

PUMPS THAT PUMP

Centrifugal and Turbine Pumps with Steam or Water Turbines. Any capacity. Any head. High efficiency. From Boiler Feed to Public Water Supply.



Wainwright Water Heater with Temperature Control.

Wainwright Corrugated Tube Heater for boiler feed.

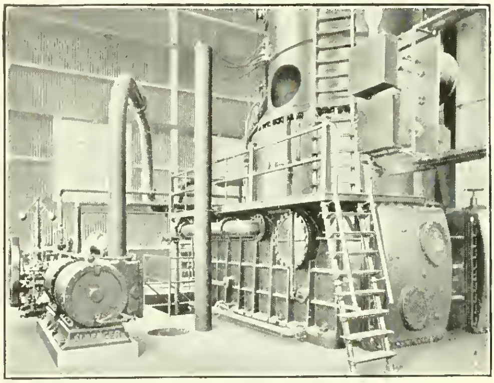
The Wainwright Spiralflow heater for hot water service, hot water heating with forced circulation and automatic regulation. High rate of heat transmission by agitation of water and counter current flow. Cast iron, copper and brass insure long life for the Wainwright Heaters.

(See also next page)

(Continued from preceding pages)

THE ALBERGER COMPANIES

ALBERGER BASE CONDENSERS



The base surface condenser is especially adapted to steam turbine conditions.

The barometric condenser of the combination counter current type makes a good outfit for a central station.

The centrifugal condenser is the simplest and most compact Jet condenser.

Self draining vacuum pumps take care of entrained water.

In the Alberger counter-current surface condenser the steam enters at the bottom, the air and uncondensable vapors are taken out at the top by means of a dry vacuum pump, the circulating water enters at the top, and passes through the tubes in a downward direction, coming out at the bottom. The water of condensation passes through the entering steam and is removed from the bottom of the condenser by means of a condensation pump.

Which of the foregoing machines should be selected for any actual situation can only be determined by a careful study of the conditions. Proximity, elevation, and character of the water supply, cost of fuel, load factor, other power units in plant, periods of running, space available, and many elements must be considered by those familiar not only with the theory but with the practice of this branch of engineering to arrive at a selection that will prove most advantageous to the user.

Our experience is at your service.

WHEELER CONDENSER AND ENGINEERING CO.

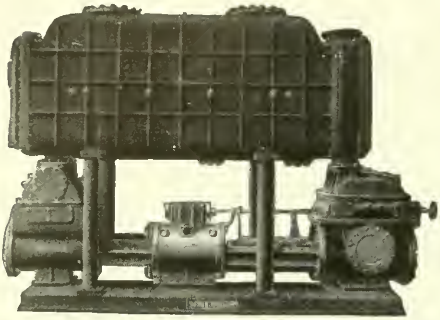
THE PIONEER AMERICAN CONDENSER BUILDERS

MAIN OFFICE AND WORKS: CARTERET, NEW JERSEY

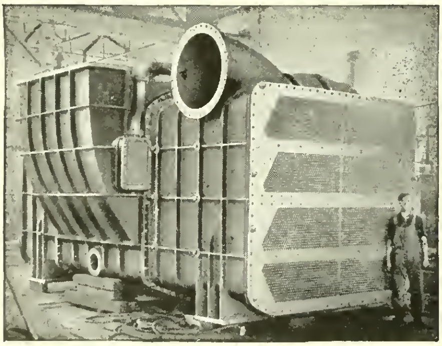
BRANCHES

New York, Boston, Philadelphia, Chicago, St. Louis, St. Paul, Cincinnati, Pittsburgh, Dallas, Cleveland, Denver, San Francisco, Salt Lake City, Los Angeles, Seattle, Portland, Tucson, Ariz., Charlotte, New Orleans, Atlanta, London, Yokahama, Trieste, Melbourne, Paris.

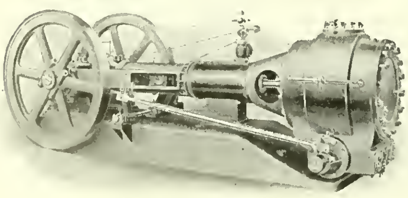
MANUFACTURERS OF COMPLETE CONDENSING EQUIPMENTS



Wheeler Admiralty Surface Condenser mounted over Combined Air and Water Pumps



Wheeler Dry Tube Surface Condenser for Steam Turbine Work



Wheeler Rotative Dry Vacuum Pump

HIGH VACUUM SURFACE CONDENSERS FOR STEAM TURBINES.

For turbines of any capacity, condensing equipments operating on wet or dry system, tube surface of condenser arranged to give best distribution of steam for high efficiency and designed on the dry tube principle to give maximum rate of heat transmission. Built as base condensers for vertical turbines, also for horizontal turbines with either rectangular or cylindrical shells. For maximum temperature of condensate, Wheeler-Volz combined condensers and feed water heaters are supplied.

HIGH VACUUM JET CONDENSERS FOR STEAM TURBINES.

For turbines of any size to maintain vacuum of 28 inches and up. Built on the countercurrent "rain type" principle to insure maximum temperature of discharge water, and therefore, minimum quantity of water, and minimum pumping cost.

WHEELER-EDWARDS AIR PUMPS, FOR AIR AND CONDENSATE.

Eliminates expense of independent air and hot well pumps. No suction or bucket valves.

WHEELER ROTATIVE DRY VACUUM PUMP.

Will maintain a vacuum within .5" of barometer. For high vacuum jet condensers and large dry tube surface condensing equipments. Clearance effect reduced by rotative sniff valve.

CENTRIFUGAL PUMPS FOR ALL SERVICES.

Circulating, tail water and hot well pumps for condensing work. Pumps of all sizes driven by motor, steam turbine or engine for water works, irrigation, etc.

FORCED DRAFT STEEL TOWERS.

Recommended for efficient cooling of water where ground space is limited, and smallest size tower must be used.

NATURAL DRAFT WOODEN TOWERS.

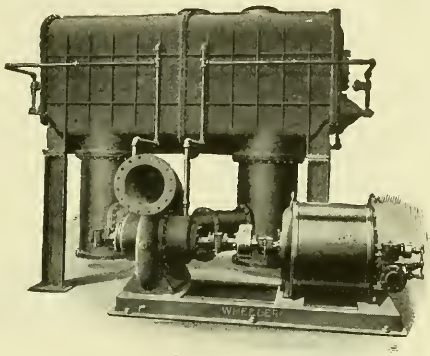
For manufacturing and industrial plants, also central stations where a supply of cooling water is not available. First cost of power low and operating cost consists of water pumping cost only. Designed for special low lift so as to reduce this cost to the minimum.

FEED-WATER HEATERS, ATMOSPHERIC EXHAUST RELIEF VALVES, VACUUM PANS, MULTIPLE EFFECTS, Etc.

WHEELER CONDENSER AND ENGINEERING CO.

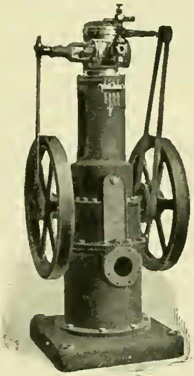
THE PIONEER AMERICAN CONDENSER BUILDERS

Wheeler Barometric Condenser



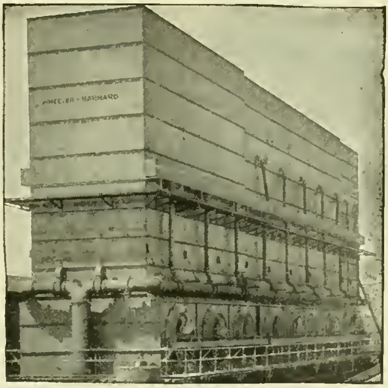
Wheeler Rectangular Jet Condenser (Counter-Current Rain Type) for High Vacuum Steam Turbines

Patented



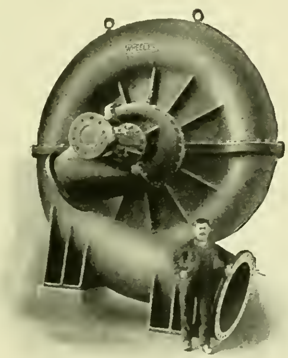
Wheeler Edwards Air Pump

Patented

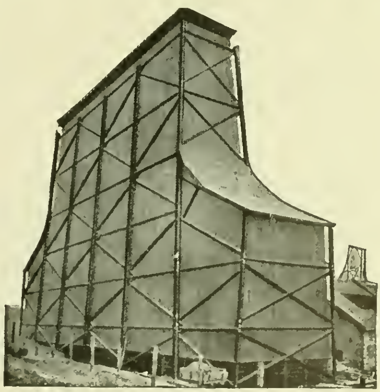


Wheeler-Barnard Forced Draft Cooling Tower

Patented



Wheeler Centrifugal Pump



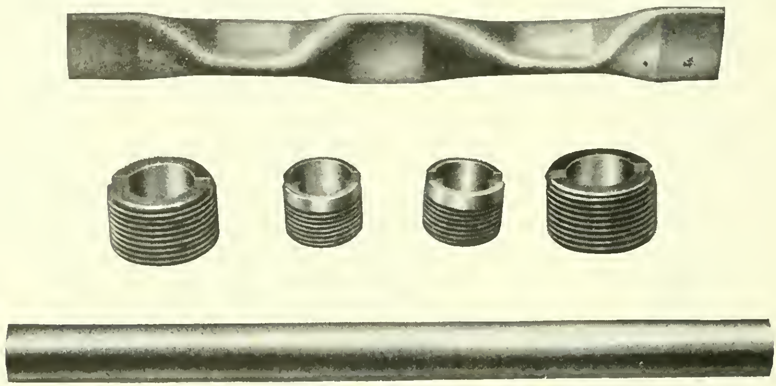
Wheeler-Balcke Natural Draft Wooden Cooling Tower

BRIDGEPORT BRASS COMPANY

96 Crescent Avenue

BRIDGEPORT, CONN.

CONDENSER TUBES OF THE HIGHEST QUALITY; "BRIDGEPORT"—BRASS AND ADMIRALTY MIXTURE; TINNED AND PLAIN. ALSO FERRULES OF ALL KINDS.



Our experience in manufacturing high grade Condenser Tubes enables us to meet the most exacting requirements. We have made a careful study of this particular class of work, and with this experience and the most approved methods at our command, *"Bridgeport" Condenser Tubes* represent quality of the highest standard.

Every tube is rigidly tested and inspected.

The severity of the requirements in modern power station service demands the highest grade of Condenser Tubes—*For Condenser Tubes of Quality specify* "Bridgeport."

Bronzes. In rod and sheet.

"Bridgeport," a special bronze. Great tensile strength and high elastic limit, for shafting, piston or plunger work. Also Manganese, Aluminum, Phosphor and Silicon Bronze.

Special shapes. Drawn or stamped from Brass, Copper, Bronze and German Silver. Send sample or blueprint for estimate of price.

ALBERGER HEATER COMPANY

BUFFALO, N. Y.

FEED WATER HEATERS AND PURIFIERS
WATER HEATERS FOR GRAVITY AND FORCED CIRCULATION HEATING SYSTEMS
HOT WATER SERVICE HEATERS FOR DOMESTIC USE

THE ALBERGER MULTI-HEAD FEED WATER HEATERS

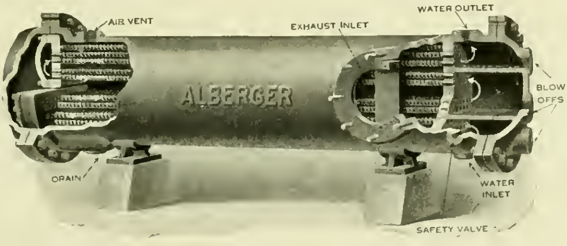
Experience has demonstrated that the most efficient way to heat water is to agitate it thoroughly, so as to bring all particles to be heated into direct contact with the heating surface. This is best accomplished in the Alberger Multi-Head Heater by breaking the water up into small columns, which in turn are broken up by the spiral corrugations in the tubes.

The Alberger Multi-Head Heater is made entirely of cast iron, except the heating surface, which is pure seamless drawn corrugated copper tubing tested to 1,000 lbs. pressure.

It is to be expected that those tubes on the cold or inlet water side of the heater, where water enters at a temperature of about 40°, will not expand nearly as much as those on the hot or outlet water side of the heater, where the temperature is 210° or practically that of the steam. It is easy to appreciate the unequal strains this difference in movement causes. In the Alberger Multi-Head Heater the design is such that the unequal expansion or contraction produced is taken care of in a very effective manner by a series of floating tube heads at one end of the heater, which permit the several groups of tubes to expand or contract entirely free from each other. This design obviates any possible trouble from the heater and assures for it a permanent life. These heaters can be furnished in either the vertical or horizontal type as may best suit existing conditions.

ALBERGER MULTI-HEAD HOT WATER SERVICE HEATER FOR DOMESTIC SUPPLY

This type of heater is used very extensively in hotels, apartment houses, offices, hospitals, schools, club houses, restaurants, laundries, turkish baths, and swimming pools and various other similar institutions. In most installations of this nature more or less exhaust steam is available for heating purposes, in which case hot water may be had at a minimum cost. In plants where exhaust steam is not available, live steam frequently is used and the heater placed at such an elevation that the water of condensation will drain by gravity back to the boiler. Where a limited amount of exhaust steam is available, but not sufficient to heat the required amount of water, the deficiency may be made up by the use of a small quantity of live steam. This may be so regulated by means of a thermostatic controlling valve, that all of the exhaust steam is utilized before live steam is admitted to the heater. In this manner a thoroughly dependable piece of apparatus is secured. In practically all instances, the instantaneous heater without storage supply accomplishes to the best advantage the desired effect. However, in laundries and some other institutions where a large quantity of hot water is required in a short period, a storage tank is sometimes provided in connection with the instantaneous heater. This is especially the case where the steam supply is limited, and the water is used at infrequent periods. It will be found that the Alberger Multi-Head Hot Water Service Heater for domestic purposes performs its functions in a very efficient manner. This heater is made in several forms to meet the particular conditions for which it is sold. The illustration below will give a comprehensive idea of the heater we recommend in order to obtain the best results.



THE SIMS COMPANY

ERIE, PENNSYLVANIA

POWER PLANT APPLIANCES, FEED WATER HEATERS, HOT WATER GENERATORS, ETC.

We issue catalogs covering our large variety of sizes and product and we incorporate valuable data for the use of the engineer. Column A of table below gives catalog number, Column B the maximum usual pressure for the apparatus, Column C the sizes made.

A	STOCK TITLE	B	C
TH2	Tubular (or closed) Feed Water Heaters. See Figs. 6 and 7	150	25
OH2	Open Feed Water Heaters and Purifiers. Fig. 5	15	15
G2	Hot Water Generators (For heating water)	50	25
M2	Sheet Iron Exhaust Heads. Fig. 2	?	21
M2	Cast-Iron Exhaust Heads		16
M2	Boiler Compound Feeders	150	5
	Sugar Juice Heaters	50	10
SS2	Steam Separators—Vertical, See Fig. 1. Horizontal, See Fig. 4	150	13
M2	Water Softeners	150	2
M2	Oil Separators. Fig. 3	20	16
M2	Oil Filters		11
	Boiler Cleaners	150	3
M2	Low Water Alarms	150	1
G2	Convertors (For heating by hot water)	50	25

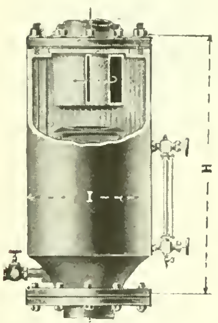


Fig. 1

Fig. 2

Fig. 3

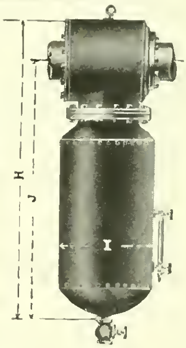


Fig. 4

Table for Fig. 5						Table for Fig. 1			Table for Fig. 4			
D	E	F	O	H	I	Dia. Pipe K	H	I	Dia. Pipe K	H	I	J
4	200	8	1½	87	25	2½	16	8½				
5	300	8	1½	73	29	3	19	10½	3	39¼	12	34
6	400	10	2	90	29	3½	19	10½	3½	39¼	12	34
7	500	10	2	92	35	4	20	12	4	42	14	36
8	600	12	2	104	35	4½	20	12	4½	42	14	36
9	800	14	3	73	43	5	22	14	5	49	16	42
10	1000	14	3	96	43	6	23	15	6	55½	18	48
11	1200	16	3	112	43	7	30	16½	7	64¼	22	56
12	1500	16	3	133	43	8	30	21	8	70½	22	60
13	2000	20	4	168	43	9	33	22	9	81	26	70
14	2500	20	4	122	64	10	33	23	10	87½	26	76
15	3000	22	5	145	64	12	34	24	12	96	30	84

NOTE. Smaller sizes are made in all the apparatus given in tables and several variations from each type are possible to suit conditions.

THE SIMS COMPANY

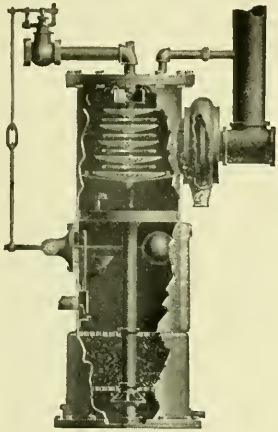


Fig. 5

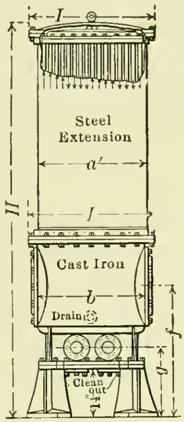


Fig. 6

Fig. 7

NOTE. The index letters given in the table refer to the dimensions given on the various apparatus illustrated above. Column D = Stock number. Column E = Horse Power Rating. Column F = Dia. of Exhaust. Column G = Water Connections. Column H = Total Height. Column I = Greatest Diameter. Column O = steam supply. All dimensions in inches.

TABLE FOR FIGURES

D	E	F	G	H	I	a'	e'	f	g	h
10	200	8	2	66	25	17		24½	12	26
11	250	8	2	78	25	17		24½	12	35
12	300	8	2½	90	25	17		24½	12	57
13	400	10	3	87	30	20		32	15	35
14	500	10	3	99	30	20		32	15	47
15	600	12	3	111	30	20		32	15	59
16	700	12	3	123	30	20		44	15	59
17	800	14	4	103	43	37	48½	40	20	
18	900	14	4	111	43	37	56½	40	20	
19	1000	14	4	119	43	37	64½	40	20	
20	1200	16	4	139	43	37	84½	40	20	
21	1500	16	4	166	43	37	112½	40	25	
22	2000	20	5	167	48½	41½	99	50	26½	
23	2500	20	5	195	48½	41½	127	50	26½	
24	3000	22	5	216	48½	41½	148	50	26½	
25	4000	22	6	260	48½	41½	191	50	26½	

AMERICAN INJECTOR COMPANY

DETROIT, MICHIGAN

("U. S.") AUTOMATIC AND ("WORLD") POSITIVE INJECTORS, "AMERICAN" EJECTORS, JET PUMPS, "GEYSER" DRIVE WELL JET PUMPS, TANK FILLERS, FIRE PLUGS, FUSIBLE PLUGS, STRAINERS, GREASE, OIL AND PRIMING CUPS, PLAIN AND SIGHT FEED LUBRICATORS, AIR AND GAUGE COCKS, WATER GAUGES, "NOISELESS" WATER HEATERS.

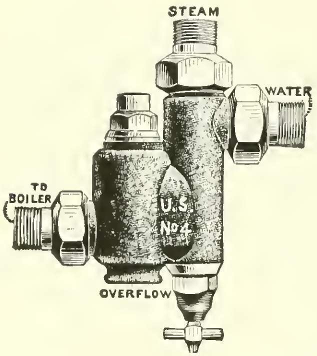
U. S. AUTOMATIC INJECTORS

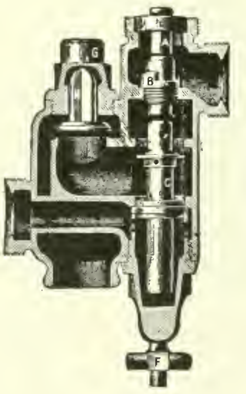
Prices and full detailed information upon request

Give 100% Efficiency. Save Time, Power, Money.

Easy to Operate. Have Wide Range. Absolutely Automatic.
Never "Break" through jarring. Backed by an Absolute Guarantee.

Study the construction. Note the Disc Valve on the Delivery Tube, the Overflow Valve and the Drip-Cock.





"The Engineer's Choice"

Every article we manufacture is characterized by exacting care and attention to every detail. Each device is tested beyond any possible requirement before it leaves our plant and is sold with an Iron-clad Guarantee of satisfactory service.

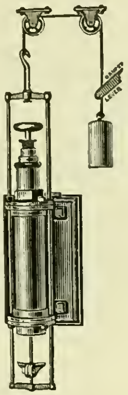
We refund the purchase price if not exactly as claimed—and we do it cheerfully.

Send for "The Engineers Red Book" and Catalog "L," with full details about U. S. Automatic Injectors, and a fund of other information which the Engineer will find of practical value in the operation of the power plant. You will receive them by return mail.

JULIAN D'ESTE COMPANY

24 CANAL ST., BOSTON, MASS.

BRASS FOUNDERS, FINISHERS AND MACHINISTS, SOLE MANUFACTURERS OF CURTIS ENGINEERING SPECIALTIES, INCLUDING DAMPER REGULATORS, IMPROVED PRESSURE REGULATORS, IMPROVED PUMP REGULATORS, WATER PRESSURE REGULATORS, EXPANSION TRAP, RETURN STEAM TRAP, BALANCED STEAM TRAP, RELIEF VALVE FOR STEAM AND WATER, STEAM SEPARATOR, TEMPERATURE REGULATOR, PUMP GOVERNOR AND PUMP, BLOWER VALVE, CELLAR DRAINER, U. S. BALL COCK, ETC.


Damper Regulator

THE CURTIS IMPROVED (PATENT) DAMPER REGULATORS

The plunger is operated by steam direct from the boiler, and the whole pressure in the boiler is therefore available to operate the damper if needed. In practice, only enough pressure is used to lift the weight, usually not more than ten pounds to the square inch on the plunger.

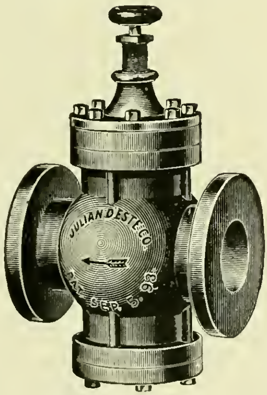
The motion of the damper will begin to change from one direction to the other on a variation of steam pressure of one half of a pound either way from the point at which it is set to operate.

We guarantee a saving of ten per cent of the fuel over the best hand regulation or the old style (diaphragm and lever regulator), and it often reaches fifteen per cent.

They are sent on thirty days' approval and will pay their cost by the saving of fuel in one year. *Three Standard Sizes.*

IMPROVED STEAM PRESSURE REGULATORS

This regulator is made entirely of metal, occupies the same space as a globe valve for the same size pipe, and is very simple and sensitive.



Steam Pressure Regulator

By its use steam may be maintained at high pressure in boilers, and yet be reduced for heating to two or three pounds.

In the best engineering practice the exhaust steam of the engine and elevator is turned into the heating system of a building, and the Regulator automatically supplies just the amount lacking to maintain constant pressure in the pipes and radiators.

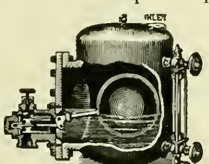
Standard sizes for 1, 1¼, 1½, 2, 2½, 3, 4, 5, 6, 7, 8, 10, 12, 14, and 16 inch pipe.

A lockup top furnished at small additional cost.

THE CURTIS BALANCED STEAM TRAP

Some Points of Superiority

1. A perfectly balanced valve.
2. An absolutely frictionless valve.
3. The valve can be removed without breaking a joint, starting a gasket, or taking out a bolt.
4. The valve being frictionless and balanced, the whole power of the float is available for opening and closing the valve.
5. The copper float is perfectly spherical, hard, as hermetically sealed as a glass globe, is of uniform thickness and warranted strong and tight at 250 lbs. pressure.
6. It has a pass-by valve to insure constant operation.
7. Each trap will operate perfectly on pressures varying from one to 250 pounds.



Balanced Steam Trap

PRICE LIST

Size and Condensing Capacity in Feet of One-Inch Pipe

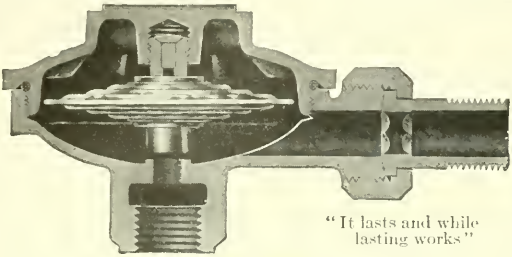
No. 000,	$15.00 for	1,000 feet	½	in. inlet and outlet
No. 00,	20.00 for	2,000 feet	½	in. inlet and outlet
No. 0,	25.00 for	3,000 feet	½	in. inlet and outlet
No. 1,	30.00 for	5,000 feet	¾	in. inlet and outlet
No. 2,	40.00 for	8,000 feet	1	in. inlet and outlet
No. 2½,	55.00 for	15,000 feet	1¼	in. inlet and outlet
No. 3,	75.00 for	30,000 feet	1½	in. inlet and outlet
No. 4,	100.00 for	40,000 feet	2	in. inlet and outlet
No. 5,	125.00 for	60,000 feet	3	in. inlet and outlet

C. A. DUNHAM COMPANY

MARSHALLTOWN, IOWA

NEW YORK: No. 1 MADISON AVE. CHICAGO: 343 S. DEARBORN ST.
SAN FRANCISCO: 637 MONADNOCK BLDG.

MANUFACTURERS OF THE DUNHAM RADIATOR TRAP, THE DUNHAM BLAST TRAP, THE DUNHAM AIR VALVE AND THE DUNHAM VACUUM AND VACUO VAPOR SYSTEMS OF HEATING



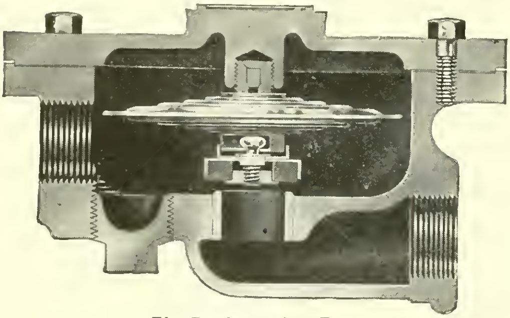
"It lasts and while lasting works"

The Dunham Radiator Trap

THE DUNHAM RADIATOR TRAP

for use in connecton with the Dunham Vacuum and Dunham Vacuo Vapor Systems of Steam Heating. It will positively allow for the complete discharge of water and air from the radiator to which it is attached without loss of steam. Constructed of phosphor bronze.

Made in four patterns—Right hand, left hand, straight way and angle. Size connections—½ inch pipe. Capacity—350 sq. ft. direct radiation. Maximum steam pressure—10 lbs. Wt.—2½ lbs.



The Dunham Blast Trap

THE DUNHAM BLAST TRAP

for use in draining blast coils in vacuum or other steam heating systems. Also for use on large direct radiating units where the Dunham Radiator Trap is too small. Positively opens for water and air and closes for steam. Body made of cast iron.

Made in one pattern only straight way.

Size	Capacity	Connection	Wt.
¾″	1500 sq. ft. direct radiation	¾″ pipe	13 lbs
1″	3000 " " "	1″ pipe	21 "

Care must be taken in reducing blast surface to equivalent direct by multiplying by a factor ranging from 3 to 9, depending upon the temperature, velocity and volume of air being forced over the coils.

THE DUNHAM AIR VALVE

This valve is made for use in revamping both old and new air-line jobs. It is built upon the same principle as the Dunham Radiator Trap. Is nickel plated all over and has union nut and nipple. Made for ⅛ inch pipe connection. Architects and engineers can specify this valve with the positive assurance that it will give service without necessitating the attention that is required to keep so many other air line valves in working order.

DUNHAM VACUO VAPOR SYSTEM

is simply a low-pressure system of heating that works upon pressure, vapor, and vacuum, without necessitating the use of a vacuum pump. It is particularly applicable to residence, apartment house, and church heating where low pressure (below 5 lbs.) boilers are used.

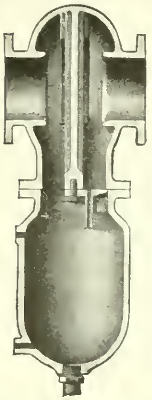
Complete information, catalog and prices will be sent on application.

The Dunham System is installed in such buildings as the Woolworth Bldg., N. Y.; 80 Maiden Lane Bldg., N. Y.; Insurance Exchange Bldg., Chicago; Sherman Hotel, Chicago, and hundreds of other buildings all over the country.

HARRISON SAFETY BOILER WORKS

3199 N. 17TH ST., PHILADELPHIA, PA.

COCHRANE FEED WATER HEATERS, COCHRANE STEAM AND OIL SEPARATORS, SORGE-COCHRANE HOT PROCESS SYSTEM OF WATER SOFTENING, COCHRANE MULTIPORT SAFETY EXHAUST OUTLET VALVES.



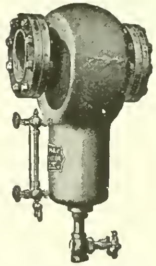
Showing general construction of horizontal form of Cochrane Separator

COCHRANE STEAM SEPARATORS protect engines, turbines or pumps from damage by water brought over from the boiler by priming, or condensed in pockets in the steam line. They also remove the small percentage of water or moisture always present in steam, thereby permitting the saving of from 25 to 50% of the cylinder oil, while obtaining better lubrication with less friction and wear. The removal of the water from steam used by turbines results in improved economy, and reduces blade erosion. Full particulars, sizes and dimensions are given in our "*Separator Catalog.*"

COCHRANE RECEIVER SEPARATORS are distinguished by extra large wells or receivers, which not only provide storage for large volumes of water until drained away by the trap, but also act as reservoirs for steam, and, being placed close to the engine throttle, equalize pulsations in the steam line and maintain a higher average pressure in the steam chest, while permitting the use of smaller piping and fittings, which are less expensive in first cost, maintenance and loss of heat by radiation. Write for Engineering Leaflet No. 10 on "*Recent Developments Affecting the Use of Separators in Connection with Live and Exhaust Steam Piping.*"

Cochrane Horizontal Receiver Separator

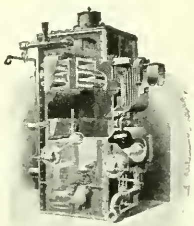
COCHRANE OIL SEPARATORS installed in exhaust lines from steam engines thoroughly purify the exhaust steam of grease or cylinder oil, so that the steam can be used safely and satisfactorily for heating water by actual contact, or in heating or drying coils, exhaust turbines, absorption ice machines and other apparatus, and so that the condensate from such apparatus may be returned and fed to the boiler, or utilized for industrial purposes. Over 10,000,000 H.P. of boilers are protected against oil by Cochrane Separators. Ask for a copy of our "*Separator Talks.*"



Cochrane Horizontal Oil Separator

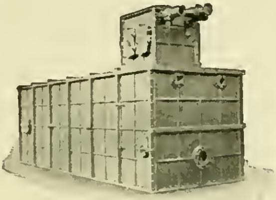
COCHRANE RECEIVER OIL SEPARATORS are used in connection with mixed flow or exhaust turbines, not only to remove the water and oil from the steam before it enters the turbine, but also serving as muffle tanks or expansion chambers, wherein the intermittent flow of steam from the engine to the turbine is equalized. We shall be glad to submit suggestions regarding any particular case upon receipt of information. See Leaflet No. 10.

THE COCHRANE OPEN FEED WATER HEATER serves as a receptacle in which the boiler feed is heated to the full temperature possible by means of exhaust steam. Spraying the water through the steam bath of the heater drives off air and gases (rendering the water non-corrosive) and brings about the precipitation of scale-forming carbonates. The Cochrane Heater also performs the functions of an automatic make-up water regulator, feed-water skimming tank and filter, oil separator and expansion or muffle tank. Cochrane Heaters are made in all sizes, up to 20,000 H.P. Our catalog of "*Cochrane Heaters and Their Use in Condensing and Non-Condensing Steam Power Plants,*" at your request.



Interior view of Cochrane Open Feedwater Heater

HARRISON SAFETY BOILER WORKS

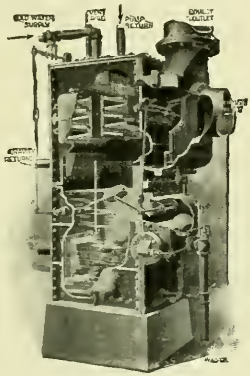


Heater with Extra Large Capacity for Storing Hot Water

COCHRANE HORIZONTAL CYLINDRICAL HEATERS are especially adapted for situations where headroom is limited, or where it is desired to provide large water storage volume.

COCHRANE HEATERS EQUIPPED WITH EXTRA LARGE STORAGE CAPACITY are supplied to paper mills, tanneries, textile mills, and other plants wherein the storage of hot water in large quantities is required.

COCHRANE STEAM-STACK AND CUT-OUT VALVE HEATERS AND RECEIVERS save from $50 to $500 on the first cost of equipping plants where the surplus exhaust steam not required in heating the boiler feed water is utilized in exhaust steam heating or drying systems or in low-pressure turbines or absorption ice machines. The extra large separator attached to the heater is of sufficient capacity to purify of oil all steam exhausted by engines, pumps, etc., thus saving the cost of an independent separator with trap in a by-pass around the heater. Valves incorporated in the application of this heater in connection with the leading commercial exhaust steam heating systems is explained in our "*Exhaust Steam Heating Encyclopedia*," sent upon request.



Cochrane Steam-Stack and Cut-Out Valve Heater and Receiver (Patented)

The formation of hard scale, and corrosion, within the boilers are prevented by the SORGE-COCHRANE HOT PROCESS WATER SOFTENING SYSTEM, which also performs all the functions of the Cochrane Open Feed Water Heater. No lime is required, the feeding of the one reagent is therefore simple and automatic, and the apparatus can be looked after by ordinary boiler room labor. Ask for pamphlet "*What Scale Does to Boilers*" and "*Hot Process System Catalog.*"

THE COCHRANE MULTIPORT SAFETY EXHAUST OUTLET VALVE is designed to release steam and prevent the accumulation of pressure in exhaust steam heating systems, surface condensers, etc. The use of a number of small disks instead of one large disk results in less danger of sticking, larger discharge opening and reduced weight and travel of disk. The position of the disk and the pressure are readily adjusted by a pressure plate to suit the degree of back pressure required, there being no heavy weights to lift. Send for *Engineering Leaflet No. 11.*

ENGINEERING SERVICE

Write us concerning the conditions in your plant, and the changes contemplated, and we shall be glad to give suggestions as to the best arrangement of apparatus to secure the results desired. We have had twenty years of experience with steam plants aggregating 10,000,000 H. P.

Address Eng. Dept., Harrison Safety Boiler Works, 3199 N. 17th St., Phila., Pa.

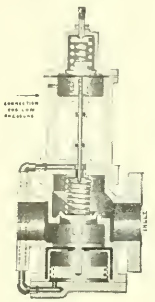
Cochrane Multiport Safety Exhaust Outlet Valve (Patented)

KIELEY AND MUELLER

34 WEST 13TH ST. NEW YORK CITY

MANUFACTURERS OF A COMPLETE LINE OF HIGH GRADE STEAM, WATER AND AIR SPECIALTIES FOR MODERN HEATING, POWER AND PLUMBING INSTALLATIONS.

HIGH PRESSURE PILOT REDUCING VALVE



Suitable for reducing steam pressures from the initial or high pressure carried, down to any pressure on the reduced side above 5 pounds that may be desired.

Made especially for reducing extreme high pressures; tested to a pressure of 400 pounds; will positively limit the reduced pressure to whatever it is set at; the only valve of this type in which the metal diaphragm can be renewed without shutting steam off the line.

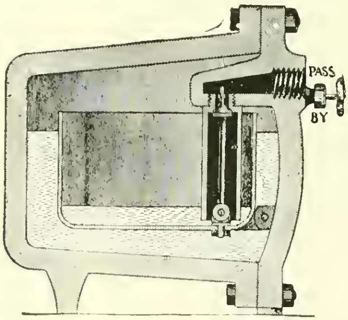
Guaranteed to deliver an absolutely steady reduced pressure, even though there is a variation of initial pressure.

The sectional cut shows this valve is of the single seat type, in consequence of which difference in the expansion of the metals of which it is constructed does not prevent it from closing absolutely tight, under the highest pressures.

KIELEY STEAM TRAPS

The few wearing parts are of standard gauge and interchangeable, obtained at a minimum of cost, easily and readily placed in position without breaking a single pipe connection. By-pass arrangements a feature and part of each trap, and many other desirable features, recognized by all familiar with these goods.

Style A—low-pressure, for pressures from 1 to 30 pounds per sq. inch. Style B—high-pressure, for pressures from 30 to 125 pounds per sq. inch. Style C—extra heavy, for pressures ranging from 125 to 250 pounds per sq. inch.



Standard Style C
Extra Heavy

OTHER PRODUCTS

- Reducing Valves for steam, water, air, etc.
- Back Pressure Valves for all purposes.
- Atmospheric Relief Valves for all purposes.
- Steam Traps for all purposes.
- Damper Regulators of various kinds.
- Hot Water Temperature Controllers.
- Steam and Water Separators.
- Oil and Grease Extractors (especially our 1906 type).
- Pump Regulators.
- Water Pressure Regulators.
- Water Feeders.
- Return Steam Traps.
- Feed Water Regulators.
- Grease and Oil Traps.
- Water Arches.
- Emergency Valves.
- Low Water Alarms.
- High and Low Water Alarms.
- Strainer Connections of various kinds.
- Drip Tank Controllers.
- Float Valves.
- Tank Pump Controllers.
- Pump Governors and Receivers.
- Combination Muffler and Grease Extractor Tank, Receiver, Pump Governor, Pump and Feed Water Heater.
- Grease Extractor and Purifier
- Waste Heat Utilizers.
- Feed Water Heater, etc.

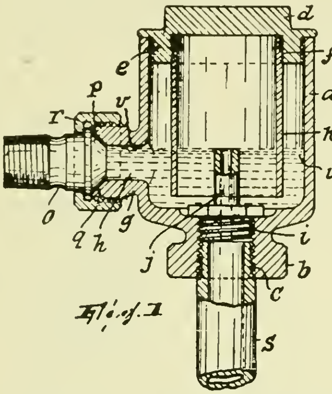
NOTICE:—Trade Mark "KILEMUL" appears on all our specialties, and are known by that name. Kindly order or specify accordingly.

COMPLETE CATALOGUE SENT ON REQUEST.

AUGUSTUS MOWELL

249 GRAHAM AVE. PATERSON, N. J.

MOWELL'S AUTOMATIC RELIEF VALVE FOR STEAM HEATING SYSTEMS



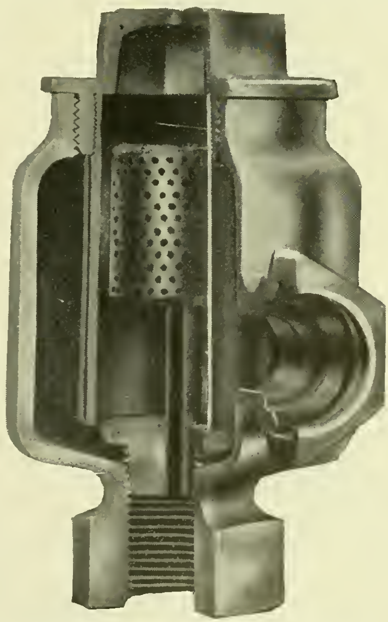
MOWELL'S AUTOMATIC RELIEF VALVE

The adjoining cut is self-explanatory. This valve has no moving parts; nothing to get out of order. Access to the valve is readily had for the purpose of cleaning, removing sediment, etc.

It is a perfect Valve for use where exhaust or other low pressure steam is used in the heating systems.

The construction is very simple: Chamber a has a nipple j extending up from the bottom and forming the outlet to pipe s; the top of this nipple is approximately in the same level as the top of inlet v. In chamber a is a depending cylinder, which projects far enough down to form with nipple j a water seal; this cylinder has a small vent k'. When steam enters the system, water of condensation first passes through the radiator and finds its way out through chamber a, via nipple j. This water is followed by air, which, being prevented by the water seal from escaping *directly* through nipple j, escapes *indirectly* through vent k'. Finally, the steam following the air, attempts to escape through k, but this at once stops because a globule of condensed steam forms and obstructs k'.

It will be clear at once that whereas water and air are *immediately* withdrawn from the system, *there is no appreciable waste of steam;* in consequence of the immediate removal of the water and air, followed directly by steam filling each radiator, *the radiators heat up immediately the system is put into operation.*



Sectional view of valve showing interior parts as in use, except that screen has been fastened up to show water seal.

USERS OF MOWELL'S AUTOMATIC RELIEF VALVE

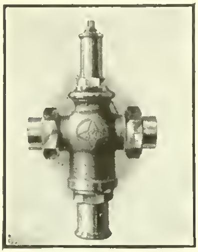
Meisch Mfg. Co., Mills: Paterson, N. J.
I. A. Hall, " " "
Henry Doherty, " Lakeview, Paterson, N. J.
P. S. Van Kirk Co., Mills: Paterson, N. J.
Pioneer Realty Co., " " "
Ralph Rosenheim, " " "
Garfield Worsted Spinning Mills, Garfield, N. J.
Atchison Harding, Mills, Passaic, N. J.
R. N. Bassett Co., Shelton, Mass.
Ira White Co., Bloomfield, N. J.
F. H. Levey Co., Brooklyn, N. Y.

THE MASON REGULATOR CO.

BOSTON, MASS.

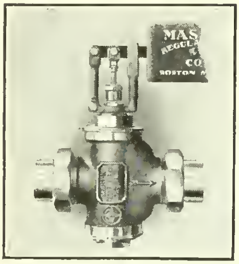
REGULATING APPLIANCES FOR STEAM, WATER OR AIR. A partial list of our product is given below. For a more complete and detailed description of the following and of many other devices, see our general catalog.

MASON ALL-BRONZE REDUCING VALVES



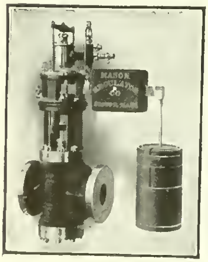
The Mason Standard Reducing Valve reduces and maintains even pressure of steam or air regardless of the variation of the initial pressure or of the volume of steam or air required. It automatically reduces boiler pressure for steam heating systems of all types (vacuum systems included), central heating plants, engines, paper machines, slashers, dye kettle and all situations where it is desirable to use a lower pressure than that on the boiler.

MASON ALL-BRONZE BALANCED VALVES



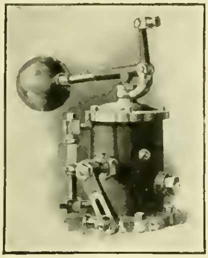
Mason All-Bronze, Balanced Valves with Yoke and Lever, are used to control pumps, engines, and the like, by means of tank floats or cords to distant points, and also in connection with various devices for controlling the flow to water wheels, receivers, open heaters, and other similar devices. They can be relied upon in any situation requiring a valve to be operated with a minimum amount of power.

MASON STEAM PUMP PRESSURE REGULATOR FOR HYDRAULIC ELEVATOR SERVICE



The Mason Steam Pump Pressure Regulator for Hydraulic Elevator Service was designed to meet the requirements of the larger sizes of steam pumps operating hydraulic elevators. The important features of this regulator are its extreme sensitiveness and quick action, as it completely opens or closes the steam valve with the slightest variation of pressure.

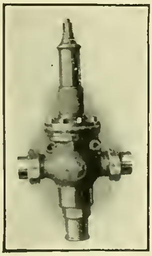
The Mason Steam Pump Pressure Regulator for Hydraulic Elevator Service has been extensively used during the past fifteen years for controlling steam pumps operating hydraulic elevators, thousands of them being in use and giving entire satisfaction.



MASON STEAM PUMP SPEED GOVERNOR

The Mason Steam Pump Speed Governor is to the direct-acting steam pump what the ordinary ball governor is to the steam engine. It derives its motion from some reciprocating part of the pump and controls a balanced valve placed in the steam pipe, thereby exactly regulating the amount of steam to the requirements of the pump, and automatically maintaining a uniform speed, regardless of any variation of steam or load.

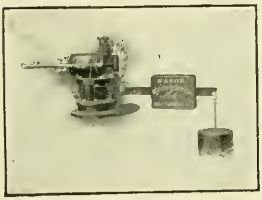
MASON STEAM PUMP PRESSURE REGULATOR



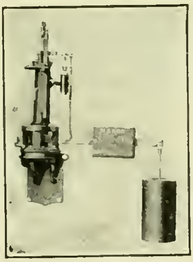
The Mason Steam Pump Pressure Regulator is designed for fire, boiler feed, air, and water works pumps, having steam supply pipe 4″ or smaller, or any class of pumping machinery where it is necessary to maintain a constant pressure.

The regulator is entirely self-contained. It is placed in the steam supply pipe to the pump and connected by $\frac{1}{4}$″ pipe to the discharge system, thereby exactly regulating the amount of steam to the requirements of the pump and automatically maintaining a uniform discharge pressure, regardless of any variation of steam pressure or demand on the pump. The regulator is provided with a dashpot, which positively prevents the pump from jumping under sudden changes of discharge pressure.

MASON HORIZONTAL PRESSURE-CONTROLLING DEVICE



The Mason Horizontal Pressure-Controlling Device, in its various modifications, is used for controlling power and electrically driven pumps of all types and on all classes of service, including vacuum systems. This device can be supplied with various sizes of diaphragms for vacuums, low pressures, and pressures up to 400 lbs., and with cup leather packed plungers for higher pressures up to 3000 lbs.



MASON HYDRAULIC DAMPER REGULATOR

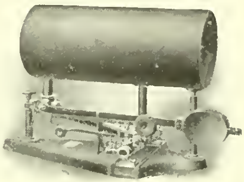
The Mason belongs to that class of Regulators which are controlled by the variation of the boiler pressure, the motive power for opening or closing the damper being the water pressure, which can either be taken from the street main or from the boiler itself. A compensating arrangement is provided which prevents the Regulator from completely opening and closing the damper at each slight change of pressure.

MOREHEAD MFG. CO.

DETROIT, MICH.

TILTING STEAM TRAPS, RETURN, NON-RETURN, VACUUM AND CONDENSER TYPES, FOR DRAINING HIGH OR LOW PRESSURE AND VACUUM HEATING SYSTEMS OF WATER OF CONDENSATION, and where desired, returning the condensation to the boiler as feed water. There is a Morehead Steam Trap to meet every condition arising in a steam or gas plant.

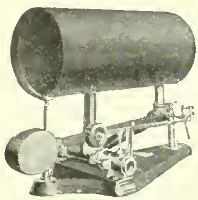
RETURN STEAM TRAP



Morehead Return Steam Trap

The Return Steam Trap removes water of condensation from heating, drying and cooking apparatus and returns the condensation direct to the boilers regardless of any difference in pressure on the apparatus drained and the boiler or whether the apparatus is located above or below the water line. It is admirably adapted for use as a lift pump and for feeding boilers from open or closed heaters. It handles perfectly, water at any temperature.

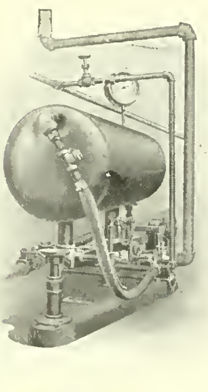
NON-RETURN TRAP



Morehead Non-Return Steam Trap

This type of Morehead Steam Trap is especially adapted to the removal of condensation from high or low pressure steam mains, dryers, heaters, etc., and delivering the water to an open tank, hot well or feed water heater. This trap has a removable seat and disc in the valve. It discharges from low point, insuring an effective *water seal* at all times. It is guaranteed for 200 lbs. working pressure.

VACUUM TRAP



Morehead Condenser Trap

This is a cut of an actual installation. The check valves and gage shown in cut are only furnished as extras.

The Vacuum Trap removes automatically all condensation from exhaust lines and oil separators operating under a vacuum without breaking or impairing that vacuum. It delivers the water of condensation to any desired point above or below the location of the trap and is guaranteed not to affect the vacuum in in any way.

CONDENSER TRAP

The Condenser Trap is a combination of the features of a Morehead Automatic Return Trap and the Jet or Spray Condenser. It is especially adapted to service on exhaust steam and reduced pressure heating, cooking and drying apparatus. The *positive vacuum* formed in the tank of the trap removes rapidly all condensation in the system, accelerates the travel of the steam and reduces the back pressure on the engine.

MOREHEAD TILTING NON-RETURN STEAM TRAPS
Sizes and Capacities

No.	Inlet Inches	Outlet Inches	Capacity in Water Discharged per Hour	Drainage Capacity in 1 inch Pipe Lineal	Capacity Square Feet Direct Radiation	Capacity Lineal Feet Hot Blast Heater	Weight
21	1	1	200 gal.	12000 ft.	3000	1300	100
22	$1\frac{1}{4}$	$1\frac{1}{4}$	400 "	25000 "	5200	2400	175
23	$1\frac{1}{2}$	$1\frac{1}{2}$	600 "	40000 "	12000	5200	250
24	2	2	720 "	60000 "	21000	9000	275
25	$2\frac{1}{2}$	$2\frac{1}{2}$	900 "	90000 "	33000	16000	350
26	3	3	1300 "	140000 "	50000	25000	450

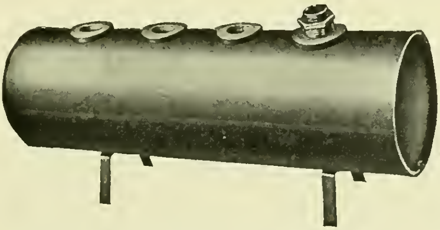
MOREHEAD TILTING RETURN AND VACUUM STEAM TRAPS
Sizes and Capacities

No.	Size of Drum	Size of Inlet and Outlet Connections Inches	Size of Steam Pipe Connections Inches	Capacity of Water in Lbs. per Hour	Drainage Capacity in feet of 1 inch Pipe Lineal	Capacity Square Feet Direct Radiation	Capacity Lineal Feet Hot Blast Heater	Weight
1	10 x 24	1	1	1050	5000	2300	1000	100
2	12 x 30	$1\frac{1}{4}$	1	1850	9000	4000	1800	175
3	14 x 36	$1\frac{1}{2}$	$1\frac{1}{4}$	4000	20000	9000	4000	250
4	16 x 40	2	$1\frac{1}{4}$	6000	35000	16000	7000	275
5	18 x 42	$2\frac{1}{2}$	2	11000	50000	25000	12000	350
6	18 x 42	3	2	15000	75000	40000	18000	400

The above capacities are figured on a basis of 50 pounds pressure to the square inch. The above drainage capacity in inch pipe is based on ordinary radiating conditions. For lumber kilns, greenhouses and moist goods, divide by two. For laundries, brick dryers and wet goods, divide by three. For fan stacks and blowers, divide by five.

NOTE—3 feet of 1 inch pipe equals one square foot of surface. 2.3 feet of $1\frac{1}{4}$ inch pipe equals one square foot of surface. 2 feet of $1\frac{1}{2}$ inch pipe equals one square foot of surface. 1.61 feet of two inch pipe equals one square foot of surface.

MOREHEAD RECEIVERS



No.	Length Inches	Height Inches	Diameter Inches
1	30	16	10
2	40	20	12

No. 1 Receiver has capacity for Traps Nos. 1 and 2. No. 2 Receiver has capacity for Traps Nos. 3, 4, 5 and 6.

We will be glad to advise regarding the installation of traps to meet the conditions of your steam system.

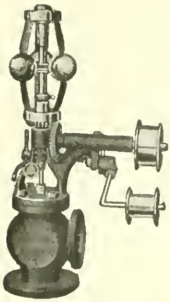
THE PICKERING GOVERNOR CO.

PORTLAND, CONNECTICUT

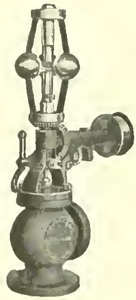
GOVERNORS FOR STEAM ENGINES, GAS ENGINES, STEAM TURBINES, MECHANICAL CONTROL AND POWER REGULATION.

Owing to the absence of joints our Governors are very responsive to slight changes in load, moving quickly and positively into correct position for maintaining the admission of steam proportionate to the duty required of the engine. Absence of joints gives maintenance in efficiency under continued and severe duty.

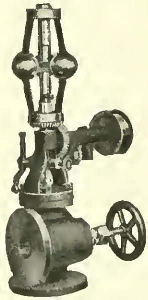
Speed Rangers are incorporated, permitting wide range in adjustment of Engine speed while running.



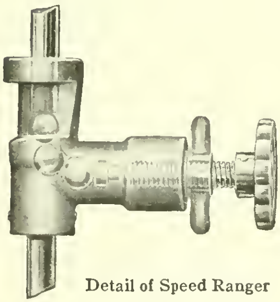
Class A



Class B Vertical

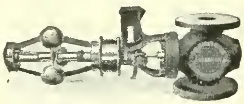


Gov. with Stop Valve



Detail of Speed Ranger

Class A Governors are equipped with safety stop which shuts off steam from the engine if governor drive belt should break. Class B are not equipped with safety stop. Horizontal B is never provided with safety stop. Governor with stop valve does away with joint between governor and valve.



Class B Horizontal

TABLE OF DIMENSIONS, ETC., FOR CLASSES A AND B

Diameter of Opening Size of Governor	$1\frac{1}{4}$	$1\frac{1}{2}$	2	$2\frac{1}{4}$	$2\frac{1}{2}$	3	$3\frac{1}{2}$	4	$4\frac{1}{2}$	5	6	7	8	9	10
From center of inlet to base...	$3\frac{1}{4}$	$3\frac{1}{2}$	$4\frac{1}{4}$	$4\frac{1}{2}$	$5\frac{1}{16}$	$5\frac{1}{2}$	$6\frac{1}{4}$	$7\frac{7}{16}$	$7\frac{5}{16}$	8	$8\frac{9}{16}$	9	10	$11\frac{1}{2}$	$11\frac{1}{2}$
Extreme Height..............	$20\frac{3}{16}$	$23\frac{31}{32}$	$25\frac{3}{32}$	$27\frac{1}{4}$	$27\frac{13}{16}$	$32\frac{5}{16}$	$33\frac{15}{16}$	$41\frac{5}{32}$	$41\frac{5}{32}$	$46\frac{1}{2}$	$49\frac{1}{8}$	$49\frac{3}{8}$	$53\frac{7}{8}$	$55\frac{7}{8}$	$60\frac{3}{4}$
Extreme expansion of Balls..	7	8	8	9	9	10	10	13	13	15	$16\frac{1}{2}$	$16\frac{1}{2}$	18	20	20
Speed of Governor..........	350	380	380	300	300	340	340	320	320	275	275	275	260	260	225
Dia. of Pulley on Gov.......	$2\frac{1}{2}$	$3\frac{1}{2}$	$3\frac{1}{2}$	4	4	4	4	5	5	5	6	7	7	8	8
Dia. of Cyl. 300 ft. Piston Sp..	6	7	9	10	12	14	16	18	20	22	26	31	36	40	45
" " " 400 " " "	5	6	8	9	10	12	14	16	18	20	23	27	31	35	39
" " " 500 " " "	$4\frac{1}{2}$	5	7	8	9	10	12	14	16	18	21	24	28	31	35
" " " 600 " " "	4	$4\frac{1}{2}$	6	7	8	9	11	13	15	16	19	22	25	28	32

For complete table and for sizes below $1\frac{1}{4}$--see our general catalogue.

POTTER SEPARATOR CO.

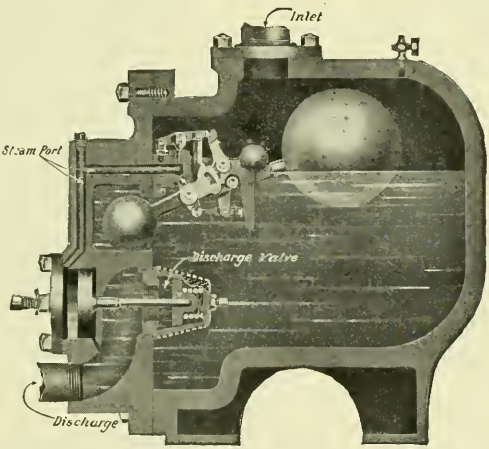
NEW YORK

WYOMING ELIMINATORS AND STEAM TRAPS

Manufactured by W. H. Nicholson & Co., Wilkes-Barre, Pa.

The purpose of a Steam Trap is to discharge water, and the price and efficiency of any trap is governed by its discharging capacity. When buying a trap the size of inlet and outlet connections are of little consequence, but ascertain the area of the discharge-valve opening. The discharge-valve openings on Wyoming Eliminators and Steam Traps range between 1″ and 4″ in diameter—hence the ability of these traps to discharge large quantities of water.

The Wyoming Eliminator, a combination steam separator of first-class design and Piston Operated Trap, both separates and discharges all moisture from the steam. It is an absolutely reliable machine for arresting "slugs" of water and discharging them at the proper moment. It is made in all sizes from 2½″ to 16″, and in Horizontal, Vertical, or Angle type.



The Wyoming Piston Operated Trap is designed especially for the purpose of taking care of large quantities of condensation, such as draining Receiver Separators, long steam lines, etc., and is guaranteed in every respect.

DIMENSIONS OF "THE WYOMING" PISTON OPERATED STEAM TRAP

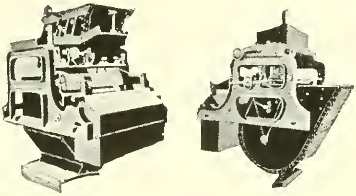
No.	Inlet	Outlet	Discharge Valve	Water discharged per hour in Gals.	Weight.
1	1¼″	1″	1″	2400	132 lbs,
2	2″	1½″	1½″	4200	260 "
3	2½″	2″	2″	6500	325 "
4	3½″	3″	3″	11520	340 "
5	4½″	4″	4″	21000	700 "

NOTE.—Capacity of discharge based on 100 lbs. pressure.

AVERY SCALE COMPANY

NORTH MILWAUKEE, WIS.

AUTOMATIC WEIGHING AND RECORDING MACHINERY



Coal and Water Scales

THE AVERY COAL AND WATER WEIGHERS

These scales have been specially designed to weigh both coal and water. They automatically weigh and register every pound of coal or water passed through them. They are made in all sizes to weigh any desired quantity per hour.

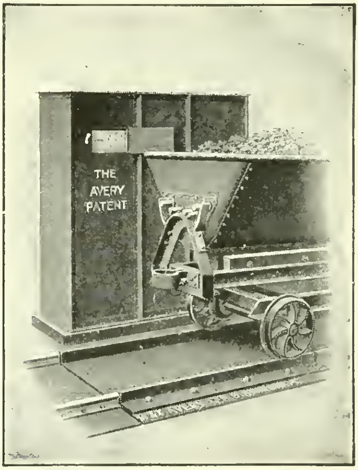
TRUCK TOTALIZER

This scale automatically weighs all cars passing over the platform and registers the net weights upon our patent counter, so that the total for any period can be immediately ascertained. The number of trucks weighed is also recorded upon a separate counter.

About one-fourth horse-power is required to operate this mechanism, and the weight of the car upon the platform automatically starts the weighing mechanism.

Empty cars passing over the platform do not affect the scale.

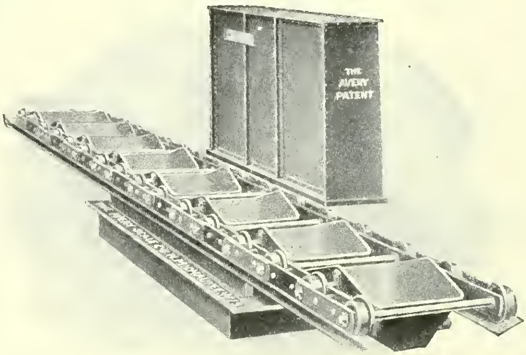
This scale can be fitted if desired with Avery's Patent Printing Apparatus, by means of which the individual weights are printed on a tape or ticket.



Truck Totalizer

CONVEYOR SCALES

This automatic conveyor scale will continuously weigh, record and total the weight of coal travelling upon any type of conveyor.

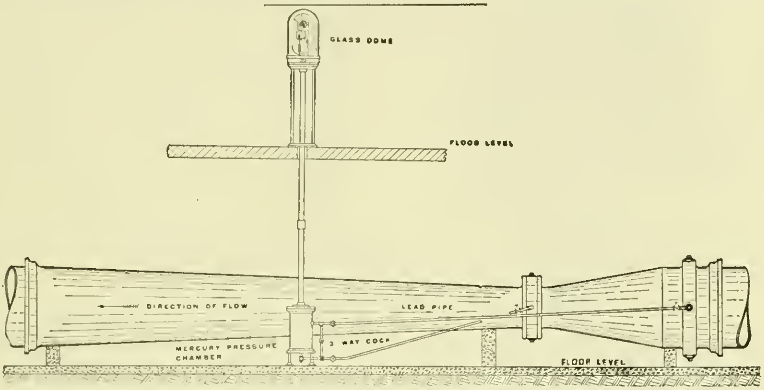


Conveyor Scales

SIMPLEX VALVE AND METER CO.

PHILADELPHIA, PA.

VENTURI AND PILOT TUBE METERS, RATE OF FLOW CONTROLLERS; LOSS OF HEAD, RATE OF FLOW, AND WATER LEVEL GAUGES, ALTITUDE VALVES FOR RESERVOIRS AND RAILROAD WATER TANKS, AUTOMATIC AIR AND VACUUM VALVES. CHEMICAL FEED DEVICES, AND OTHER HYDRAULIC APPARATUS OF SPECIAL DESIGN.



Standard setting for low pressure type where Piezometric level of water in main is below desired location of meter register

SIMPLEX TYPE "G" WATER METER

Our type "G" Simplex meter, which is thoroughly covered by pending United States patents, is based on the principles discovered in 1904, finally perfected in 1909 and fully developed and tested out in 1910. The important features are the ability to measure all flows from zero to any desired maximum without theoretical or practical limitation.

It consists of some form of orifice such as a Venturi Tube, pitot tube in a water main, any form of conduit, or canal, and having suitable pipe connections therewith. The apparatus consists of a mercury float chamber, and resting therein a float of such variable cross section that its movement is in direct ratio to the flow of water through the Venturi tube, pipe. conduit, or canal. The movement of the float actuates a revolving shaft to which is attached a hand pointing to a fixed dial with uniform graduations. Attached to the shaft and moving in proportion to the angular deflections thereof is a pen in contact with a rectangular chart wrapped on a revolving cylinder; also a traction wheel, which passes over the face of a revolving disc, said traction wheel being geared to a train of wheels operating a series of small dials similar to that of a house gas or water meter. Both the cylinder and the disc are operated by an eight day marine clock.

SIMPLEX RATE-OF-FLOW CONTROLLERS

This apparatus is designed for service in a water pipe or conduit through which the rate of discharge must be maintained uniform, regardless of the pressure or head on the up or down stream side of the valve. It consists of a perfectly balanced valve, operated by a diaphragm, a Venturi section or tube, and means whereby the diaphragm is actuated by the difference in pressure between the full and contracted sections of the Venturi tube. The diaphragm and valve are balanced by an adjustable counterweight, which, when set for any required rate of flow, will hold the valve discs in the proper position for that flow.

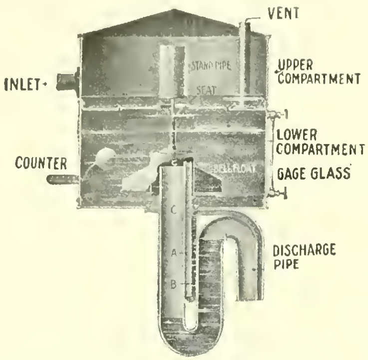
In every well-regulated filter plant, wherein rate controllers are used, it is the invariable custom to also provide for loss-of-head and rate-of-flow gauges. To adjust our controller, it is only necessary to watch the rate-of-flow gauge and move the counterweight so as to produce the rate of flow desired, after which the mechanism will automatically maintain this rate until the counterweight is readjusted. Where rate-of-flow gauges are not used, the graduation on the scale beam can be used for this purpose.

Complete catalogs on request.

WILLCOX ENGINEERING CO., Inc.

SAGINAW, MICHIGAN, U. S. A.

THE WILLCOX WATER WEIGHER.



Vertical Section of the Willcox Water Weigher Style A

The Willcox Water Weigher is a device for automatically weighing and recording the water fed to boilers. It takes water from any source, such as a feed water heater, tank, pump, or hydrant, at any rate of flow or at varying rates, and delivers it intermittently in charges of uniform weight.

It will weigh hot feed water from an open heater, cold water from a hydrant, water of condensation from vacuum pans or heating systems; also chemicals, volatile oils, sugar juices, etc.

Operation: The charge is balanced by a liquid column of fixed height, through the medium of an air balance. The unit charge is dumped automatically by the sudden release of the entrapped air—an extremely accurate method of balancing.

Accuracy: Each weigher is guaranteed to weigh within one per cent. of absolute accuracy at any rate of supply up to its maximum capacity and at any temperature from freezing to boiling.

Styles and Capacities: The Willcox Water Weigher is built in several styles to suit various requirements, and in all capacities from one thousand pounds per hour up to half a million pounds.

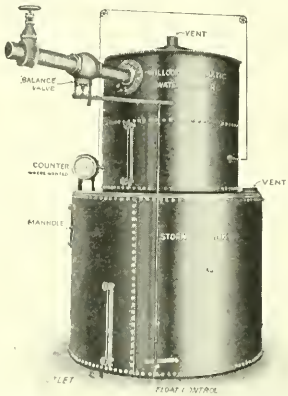
Plans for Installation: Suggestions, sketches and plans for proposed installations are furnished free of charge by the Willcox Engineering Company. We have competent engineers and draftsmen for the purpose of assisting prospective customers in planning suitable arrangements to meet local conditions.

Savings Secured in Boiler Plants: By furnishing a simple, reliable, automatic, self-recording device for continuously and accurately recording every pound of water pumped to the boilers, the Willcox Water Weigher offers a means of segregating boiler evaporation cost from engine and generator costs, thereby giving a sure means of determining from day to day whether or not a proper evaporation is being secured per pound of coal.

GENERAL DIMENSIONS—STYLE A BUILT OF BOILER PLATE

Size No.	Maximum rate of weighing, in lbs. of water per hour	Size Inlet, In.	Shell Thickness	Approximate	
				Ship'g Weight	Weight of of water per unit charge
1	500,000	10	$\frac{3}{8}$	4000	5000
2	400,000	8	$\frac{3}{8}$	3600	. . .
3	300 000	8	$\frac{5}{16}$	3000	3500
4	250,000	6	$\frac{5}{16}$	2600	. . .
5	200,000	6	$\frac{1}{4}$	2100	2700
6	175,000	6	$\frac{1}{4}$	2000	. . .
7	150,000	6	$\frac{1}{4}$	1850	2250
8	125,000	6	$\frac{1}{4}$	1700	. . .
9	100,000	6	$\frac{3}{16}$	1500	1800
10	87,500	4	$\frac{3}{16}$	1350	. . .
11	75,000	4	$\frac{3}{16}$	1200	. . .
12	62,500	4	$\frac{3}{16}$	1100	1180
13	50,000	4	$\frac{3}{16}$	1000	. . .

Illustrated Catalog No. 3 sent on request.



The Willcox Automatic Water Weigher with Storage Tank. Style A

JEFFERSON UNION COMPANY

LEXINGTON, MASS.

UNIONS AND FLANGES FOR OIL, STEAM, WATER AND GAS UNDER ALL PRESSURES. Malleable iron only is used for standard goods and brass tubing for rings for seats.

Three Part **STYLE B FLANGE (Fig. 3)**

Pipe Size	$\frac{1}{2}$	$\frac{3}{4}$	1	$1\frac{1}{4}$	$1\frac{1}{2}$	2	$2\frac{1}{2}$	3	$3\frac{1}{2}$
Outside Diameter	$2\frac{7}{8}$	$3\frac{5}{32}$	$3\frac{3}{4}$	$4\frac{3}{16}$	$4\frac{1}{2}$	$5\frac{9}{16}$	$6\frac{5}{16}$	$6\frac{11}{16}$	$7\frac{11}{16}$
Length Over all	$2\frac{1}{4}$	$2\frac{3}{8}$	$2\frac{21}{32}$	$2\frac{15}{16}$	$3\frac{3}{16}$	$3\frac{7}{16}$	$3\frac{11}{16}$	$3\frac{15}{16}$	$4\frac{1}{4}$

Pipe Size	4	$4\frac{1}{2}$	5	6	7	8	9	10
Outside Diameter	9	$9\frac{9}{16}$	$10\frac{1}{16}$	$11\frac{3}{8}$	$12\frac{7}{16}$	14	15	$16\frac{1}{4}$
Length Over all	$4\frac{1}{2}$	$4\frac{5}{8}$	$4\frac{13}{16}$	$4\frac{15}{16}$	$5\frac{3}{16}$	$5\frac{5}{16}$	$5\frac{9}{16}$	$5\frac{27}{32}$

Two Part **STYLE D FLANGE (Fig. 4)**

Pipe Size	$\frac{1}{2}$	$\frac{3}{4}$	1	$1\frac{1}{4}$	$1\frac{1}{2}$	2	$2\frac{1}{2}$	3	$3\frac{1}{2}$
Outside Diameter	$2\frac{7}{8}$	$3\frac{11}{32}$	$3\frac{11}{16}$	$4\frac{1}{8}$	5	$5\frac{21}{32}$	$6\frac{1}{4}$	7	$7\frac{5}{8}$
Length Over all	$2\frac{5}{16}$	$2\frac{7}{16}$	$2\frac{21}{32}$	$2\frac{25}{32}$	$2\frac{31}{32}$	$3\frac{1}{32}$	$4\frac{1}{8}$	$4\frac{5}{16}$	$4\frac{15}{32}$

Pipe Size	4	$4\frac{1}{2}$	5	6	7	8	9	10	12
Outside Diameter	$8\frac{3}{4}$	$9\frac{5}{16}$	10	$11\frac{7}{32}$	$12\frac{11}{32}$	$13\frac{31}{32}$	$15\frac{1}{16}$	$16\frac{9}{32}$	$18\frac{3}{8}$
Length Over all	$4\frac{19}{32}$	$4\frac{23}{32}$	$4\frac{27}{32}$	$5\frac{3}{32}$	$5\frac{11}{32}$	$5\frac{19}{32}$	$5\frac{27}{32}$	$6\frac{5}{32}$	$6\frac{21}{32}$

STYLE E FLANGE (Fig. 4)

Two Part—Extra Heavy

Pipe Size	1	$1\frac{1}{4}$	$1\frac{1}{2}$	2	$2\frac{1}{2}$	3	$3\frac{1}{2}$	4
Outside Diameter	$4\frac{1}{8}$	$4\frac{9}{16}$	$5\frac{3}{16}$	6	$6\frac{31}{32}$	$7\frac{3}{4}$	$8\frac{3}{8}$	$9\frac{17}{32}$
Length Over all	$3\frac{17}{32}$	$3\frac{25}{32}$	$4\frac{1}{32}$	$3\frac{23}{32}$	$4\frac{3}{4}$	$4\frac{15}{16}$	$5\frac{3}{32}$	$5\frac{7}{32}$

Pipe Size	$4\frac{1}{2}$	5	6	7	8	9	10
Outside Diameter	$10\frac{5}{32}$	$10\frac{27}{32}$	$12\frac{1}{8}$	$13\frac{13}{16}$	$14\frac{31}{32}$	$16\frac{3}{32}$	$17\frac{5}{16}$
Length Over all	$5\frac{11}{32}$	$5\frac{17}{32}$	$5\frac{27}{32}$	$6\frac{5}{32}$	$6\frac{13}{32}$	$6\frac{23}{32}$	$7\frac{1}{32}$

Jefferson Style A Unions (Fig. 2) are made with spherical brass to iron seats ground to a perfect fit. The ring *A* is of wrought metal, cut from seamless brass tubing, avoiding blowholes common in cast brass. There are special advantages in the use of the brass ring in just the manner shown and the wall *B* is patented owing to these advantages, which include protecting the brass from injury no matter how far the pipe is screwed in. No gasket is used and there is plenty of play for the part *F* which swivels in the nut. Dimensions are given in following table.

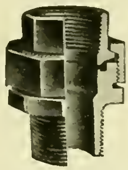


Fig. 1

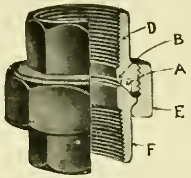


Fig. 2

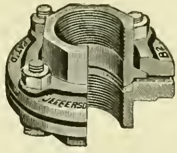


Fig. 3

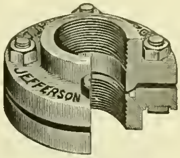


Fig. 4

STYLE A UNION

"Standard Type" All Female

Pipe Size	$\frac{1}{8}$	$\frac{1}{4}$	$\frac{3}{8}$	$\frac{1}{2}$	$\frac{3}{4}$	1	$1\frac{1}{4}$
Diameter Nut (Across Flats)................	$1\frac{3}{16}$	$1\frac{13}{32}$	$1\frac{37}{64}$	$1\frac{13}{16}$	$2\frac{1}{8}$	$2\frac{33}{64}$	3
Length Over all............................	$1\frac{33}{64}$	$1\frac{45}{64}$	$1\frac{57}{64}$	$2\frac{3}{32}$	$2\frac{9}{32}$	$2\frac{1}{2}$	$2\frac{3}{4}$

Pipe Size	$1\frac{1}{2}$	2	$2\frac{1}{2}$	3	$3\frac{1}{2}$	4
Diameter Nut (Across Flats)................	$3\frac{13}{32}$	$4\frac{7}{32}$	$4\frac{59}{64}$	$5\frac{23}{32}$	$6\frac{9}{16}$	$7\frac{27}{64}$
Length Over all............................	3	$3\frac{7}{16}$	$3\frac{29}{32}$	$4\frac{11}{32}$	$4\frac{11}{16}$	$4\frac{63}{64}$

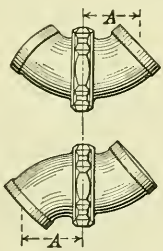
The Jefferson Style F Union (Fig. 1) is short and more easy to use than the union and nipple which it replaces. It has Briggs Std. pipe threads. Any kind of wrench may be used on any of its parts.

STYLE F UNION

Male and Female

Pipe Size	$\frac{1}{4}$	$\frac{3}{6}$	$\frac{1}{2}$	$\frac{3}{4}$	1	$1\frac{1}{4}$	$1\frac{1}{2}$	2	$2\frac{1}{2}$	3
Diameter Nut (Across Flats)...	$1\frac{13}{32}$	$1\frac{37}{64}$	$1\frac{13}{16}$	$2\frac{1}{8}$	$2\frac{33}{64}$	3	$3\frac{13}{32}$	$4\frac{7}{32}$	$4\frac{59}{64}$	$5\frac{23}{32}$
Length Over all	$2\frac{5}{32}$	$2\frac{11}{32}$	$2\frac{11}{16}$	$2\frac{57}{64}$	$3\frac{17}{64}$	$3\frac{17}{32}$	$3\frac{3}{4}$	$4\frac{13}{64}$	$5\frac{1}{8}$	$5\frac{35}{64}$

SWING UNION



Pipe Size	$\frac{1}{6}$	$\frac{1}{4}$	$\frac{3}{8}$	$\frac{1}{2}$	$\frac{3}{4}$
Diam. Nut (Across Flats)...............	$1\frac{3}{16}$	$1\frac{7}{16}$	$1\frac{41}{64}$	$1\frac{29}{32}$	$2\frac{1}{4}$
Length A...............................	$1\frac{11}{64}$	$1\frac{23}{64}$	$1\frac{31}{64}$	$1\frac{11}{16}$	$1\frac{65}{64}$

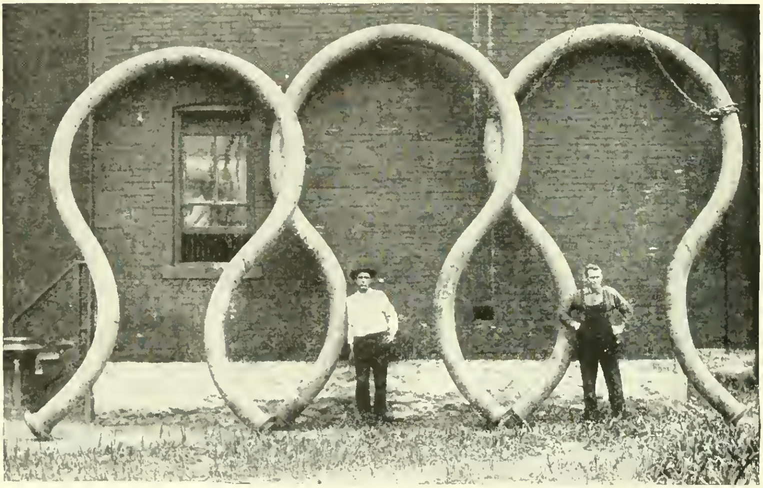
Pipe Size	1	$1\frac{1}{4}$	$1\frac{1}{2}$	2	$2\frac{1}{2}$
Diam. Nut (Across Flats)	$2\frac{43}{64}$	$3\frac{7}{32}$	$3\frac{21}{32}$	$4\frac{17}{32}$	$5\frac{21}{64}$
Length A...............................	$2\frac{9}{64}$	$2\frac{3}{8}$	$2\frac{37}{64}$	$2\frac{63}{64}$	$3\frac{5}{8}$

BEST MANUFACTURING CO.

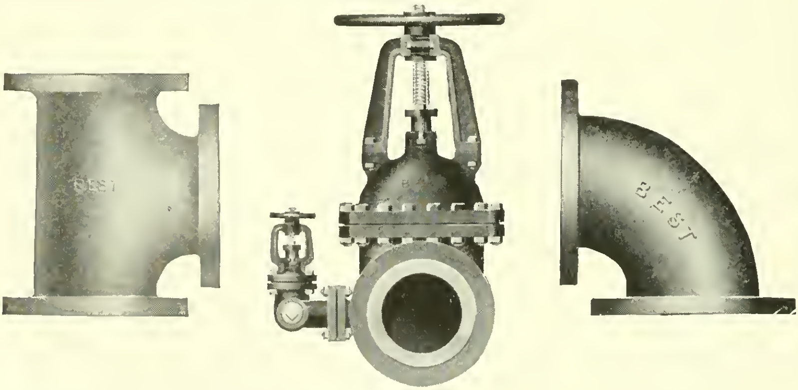
PITTSBURGH, PA.

WORKS, - OAKMONT, PA.

PIPE **VALVES** **FITTINGS**



FABRICATED PIPING WORK FURNISHED COMPLETE—DESIGNS FOR PLANT SYSTEMS SUBMITTED.



PIPING—For all services, all pressures.

VALVES—All Iron, Semi-Steel, Cast Steel. "Best" Double Adjustable wedge Gate Valves.

FITTINGS—Iron, Brass, Semi-Steel, Cast Steel.

SPECIALTIES—Welded and Vanstone Flanges, Welded Headers, Large Castings, "Best" and Moran Type Flexible Joints, Bosh Piping, Tuyere Cocks, etc.

1912 CATALOG No. 103—Illustrating our line, sent upon request on company letterhead.

THE CHAPMAN VALVE MFG. CO.

INDIAN ORCHARD, MASS.

STEEL PARALLEL SEAT, DOUBLE GATE VALVE FOR SUPERHEATED STEAM
STEEL BODIES AND BONNETS, MONEL METAL GATES AND SEATS

STRAIGHTWAY TYPE

Fig. 312 is a cut of the internal working parts, showing the carrier block extended to carry an opening the full size of the pipe line, so that when the valve is fully open the seats are covered and the pipe line is made continuous, the carrier extension effectually filling up the aperture around the seats.

The valve when open is the same as if it were a continuation of the pipe line, with neither contractions or apertures of any kind to deflect or break up the flow of the steam. This construction not only prevents the loss of head due to eddying, but it also protects the seats from injury.

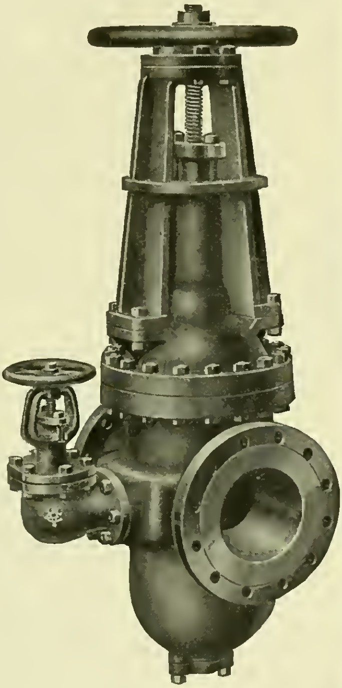


Fig 311

Diameter of Port or Size=**A**
Face to Face Flanges=**B**
Diameter of Flanges=**C**

A	2	2½	3	3½	4	4½
B	10¼	12½	14	14¾	18½	18½
C	6½	7½	8¼	9	10	10½
A	5	6	7	8	9	10
B	18½	19	20	20⅝	21⅞	22¾
C	11	12½	14	15	16	17½
A	12	14	16	18	20	24
B	23¾	25⅞	32⅞	33¼	35¼	35⅞
C	20	22½	25	27	29½	34

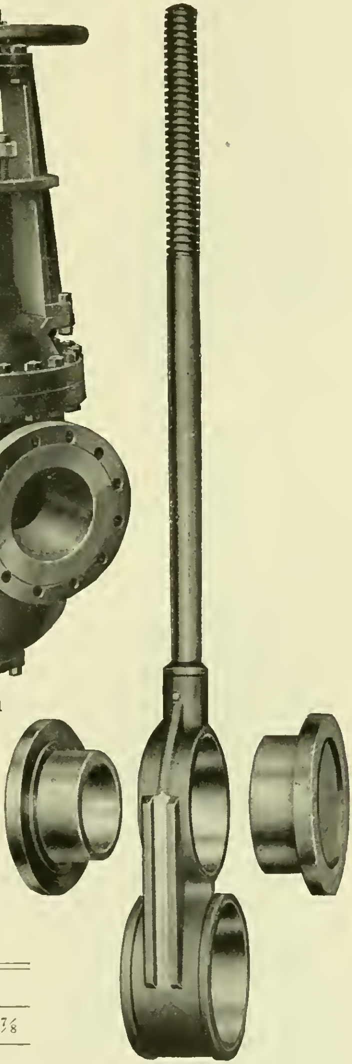


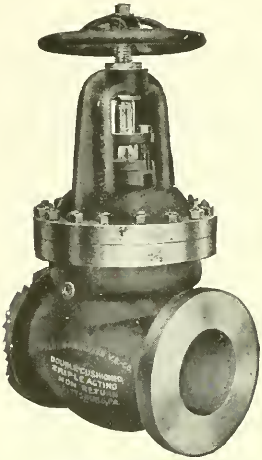
Fig 312

PAGES 64-65 CATALOGUE NO. 30

GOLDEN-ANDERSON VALVE SPECIALTY CO.

1219 FULTON BLDG. PITTSBURGH, PA.

STEAM AND WATER SPECIALTIES



Triple Non-Return Valve

AUTOMATIC DOUBLE-CUSHIONED TRIPLE-ACTING NON-RETURN VALVES

(Angle or Globe)

"Works Both Ways;" automatically protects the boilers and steam lines.

Placed in the boiler outlet this valve will permit the passage of steam to the header or main, as required in regular service, but will close quickly against a reversal of the current. In case of accident to the boiler this valve will isolate the disabled unit from the rest of the battery, thereby not only reducing the destructive results of the accident, but also confining the damage to this one boiler and avoiding, oftentimes, the necessity for any interruption in the operation of the rest of the battery.

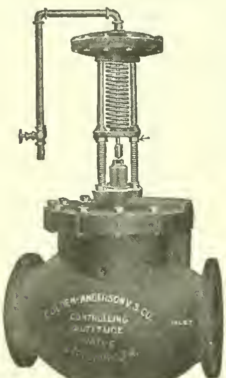
1009 of these were ordered by the largest steam users in the World for the protection of their power plants.

THE CONTROLLING ALTITUDE VALVES

Automatically maintain a uniform stage of water in standpipes, reservoirs or tanks.

No overflow in case of fire pressure.

Valves closed by water or electricity.



Controlling Altitude Valve

FLOAT VALVES

Instantly adjusted to operate quickly or slowly as desired. Indestructible.

They are an absolutely satisfactory Float Valve for high or low pressure.

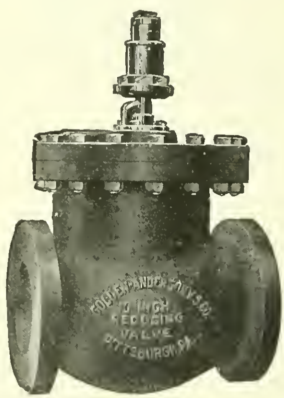
ANDERSON REDUCING VALVES

For Steam or Water

are always cushioned in opening or closing. Regular sizes up to 24 in. dia.

Manufacturers also of STANDPIPE VALVES, ELECTRO-HYDRAULIC VALVES, AUTOMATIC VALVES.

Float Valve—angle or straight-way



Reducing Valve

HOMESTEAD VALVE MANUF'G CO.

PITTSBURGH, PA.

THE HOMESTEAD SELF-LOCKING STRAIGHTWAY, THREE-WAY AND FOUR-WAY HIGH PRESSURE BALANCED PLUG VALVES. THE HOMESTEAD LOCKING COCK.

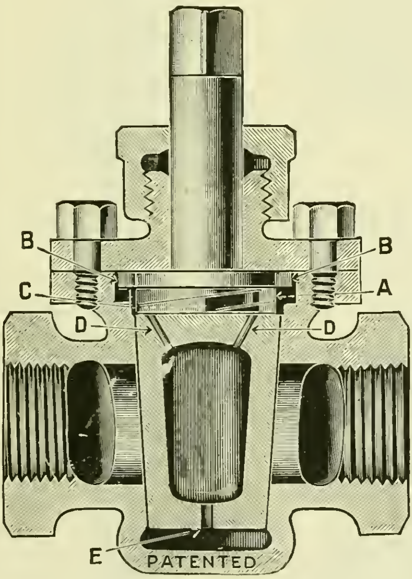
THE HOMESTEAD SELF-LOCKING STRAIGHTWAY VALVE

This valve is unlike all others for the reason that when the pressure passes through it the seat is ABSOLUTELY PROTECTED FROM WEAR. The plug is balanced and held in place by the pressure when open, and when closed it is locked in the seat by our patent wedging cam, insuring freedom from friction in seat while plug is turning, which makes ours the quickest acting, simplest made, easiest operated and most durable valve known. Globe and Gate Valves, on the other hand, have their vital parts (Seats) EXPOSED to pressure and destruction every moment they are open.

CONSTRUCTION

This valve is so constructed that when it is closed it is at the same time forced firmly to its seat. This result is secured by means of the traveling cam "A" through which the stem passes. The cam is prevented from turning with the stem by means of the lugs "B" which move vertically in slots. Supposing the valve to be open, the cam will be in the lower part of the chamber in which it is placed, and the plug will be free to be easily moved. A quarter of a turn in the direction for closing it causes the cam to rise and take a bearing on the upper surface of the chamber, and the only effect of further effort to turn the stem in that direction is to force the plug more firmly to the seat. A slight motion in the other direction immediately releases the cam and the plug turns easily, being arrested at its proper open position by contact of the fingers of the cam at the other end of its travel. E. D. D. are balancing ports which allow the pressure to predominate at the top of plug, holding it gently in its seat while valve is open. Made in all sizes up to six inches, and for all pressures up to 5,000 pounds per square inch. Made in Straight Way, Three and Four-Way Patterns.

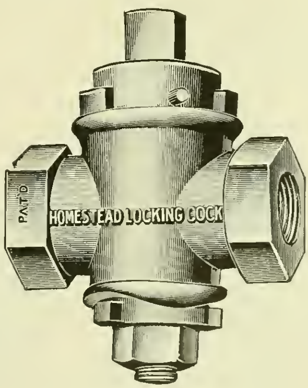
For Steam, Compressed Air and Hydraulic Service.



Homestead Straightway Valve

THE HOMESTEAD LOCKING COCK

is made with a double external locking device, which forces absolutely tight adherence of the plug to the seat at each end of the quarter turn to which it is limited, insuring easy turning and almost entire freedom from wear, giving you SIMPLICITY, RAPIDITY and DURABILITY combined.



The Homestead Locking Cock

THE KENNEDY VALVE MFG. CO.

MAIN OFFICE AND WORKS: ELMIRA, N. Y.

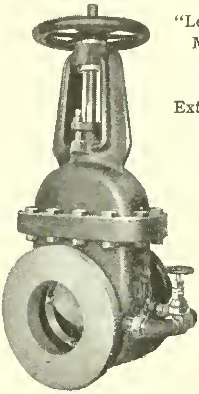
Agencies:

57 Beekman St., New York City — 602 Western Union Bldg., Chicago

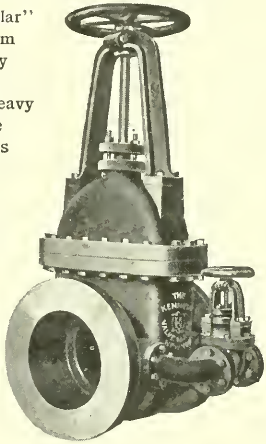
Monadnock Bldg., San Francisco — 604 Canal-Louisiana Bank Bldg., New Orleans

GATE, GLOBE, ANGLE, CHECK, RADIATOR AND INDICATOR VALVES FOR POWER, HEATING, PLUMBING AND AUTOMATIC SPRINKLER INSTALLATIONS

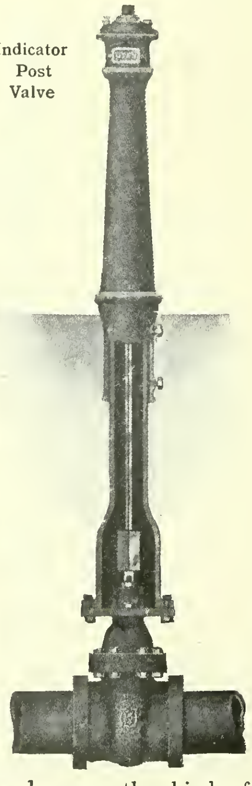
FIRE HYDRANTS



"Lenticular" Medium Heavy and Extra Heavy Gate Valves

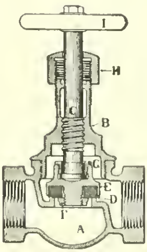


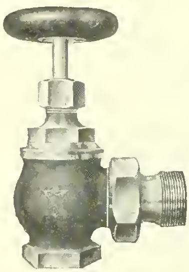
"Standard" Bronze Gate Valve

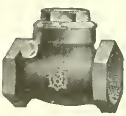


Indicator Post Valve

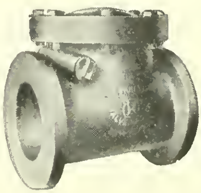
Globe and Radiator Valves with Goodrich Elastic Renewable Disc







Swinging Check Valves



Write for catalogue "X," describing all the above and many other kinds of valves.

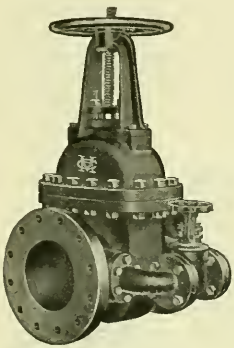
MONARCH VALVE AND MFG. CO.

SPRINGFIELD, MASS.

NEW YORK BOSTON CLEVELAND PHILADELPHIA

HIGH GRADE VALVES FOR STEAM, WATER, GAS, AIR, OIL, AMMONIA, BRINE, ETC. MADE OF THE BEST STEAM BRONZE, GRAY IRON OR STEEL.

The table below gives a partial list of our regular product.



LIST	DESCRIPTION
1	Bronze Gate, 125 lbs. Steam, 250 lbs. Water Pressure.
2	" " 250 " " 400 " " "
3	" " 800 " Water Pressure.
4	" " 2000 " " "
5	" " 6000 " " "
6	" Globe, 125 " Steam, 250 lbs. Water Pressure.
7	" " 250 " " 400 " " "
8	" Check, 125 " " 250 " " "
9	" " 250 " " 400 " " "
10	" Navy, 50 " Pressure.
11	" " 300 " "
12	" " 500 " "
15	Iron Body Gate, 80 lbs. Steam. 150 lbs. Water Pressure.
16	" " " 125 " " 200 " " "
16½	" " " 150 " " Pressure.
17	" " " 250 " " 400 lbs Water Pressure.
18	" " Globe, 125 " " 200 " " "
19	" " " 250 " " 400 " " "
20	" " Check, 125 " " 200 " " "
21	" " " 250 " " 400 " " "
22	Steel " Gate, 250 " " 400 " " "
23	" " Globe, 250 " " 400 " " "
24	" " Check, 250 " " 400 " " "

THE MONARCH LOOSE NECK GATE

The cuts below illustrate our method of connecting gate and spindle. The spindle is threaded into a third member, which fits into a slot at the top of gate. There is a slight amount of play between these parts, so that the gate closes without catching or binding, and without uneven wear or side strain on spindle.

THE LUDLOW VALVE MFG. CO.

TROY, NEW YORK

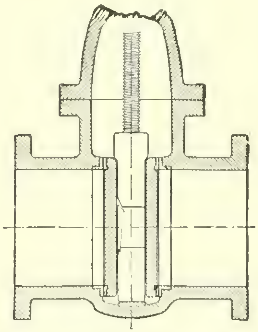
BRANCH OFFICES

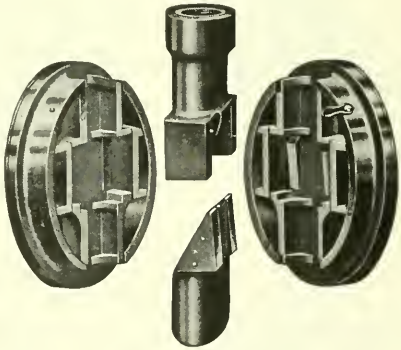
NEW YORK: 62 Gold St.
BOSTON, MASS.: 182 High St.
PITTSBURGH, PA.: Farmer's Bank Bldg.
CHICAGO, ILL.: 633-635 The Rookery
PHILADELPHIA, PA.: Harrison Bldg.
KANSAS CITY, MO.: Victor Bldg.

HIGH GRADE VALVES FOR EVERY PURPOSE; VALVES FOR OIL, WATER, STEAM, GAS AND AMMONIA, OF ANY SIZE AND FOR ALL PRESSURES; AUTOMATIC AIR VALVES AND FLOAT VALVES; RELIEF VALVES; SLUICE GATES; CHECK AND FOOT VALVES; COMBINATION AIR VALVE WITH CONTROLLING GATE; HYDRANTS.

THE LUDLOW DOUBLE GATE VALVE

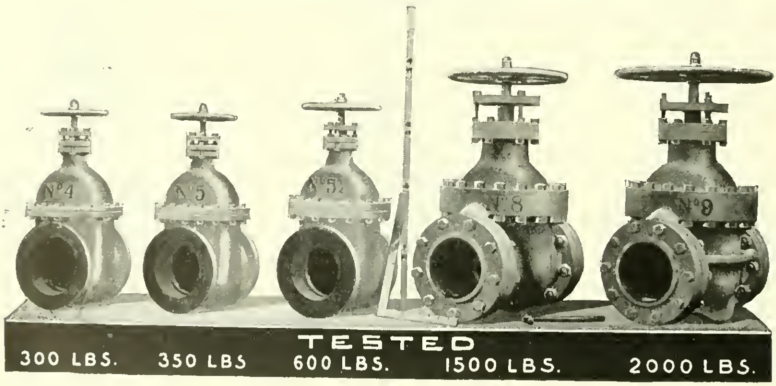
The illustrations below show section of valve and detailed view of the Gates and Wedges. The Gates cannot lock or wedge in closing until directly opposite the ports. Gates are released from seats before starting to rise, avoiding wear on seats, and grinding or dragging of faces of gates on seats is impossible. Stem cannot bind or wedge. The gates cannot cant to either side and cause stripping of threads on stem.



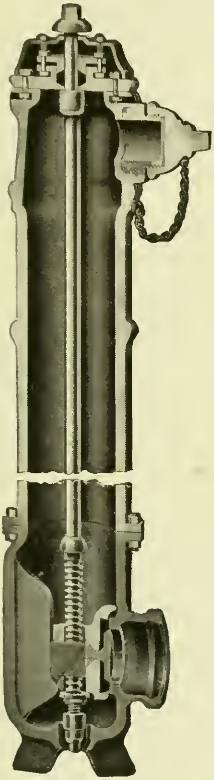


LUDLOW DOUBLE GATE VALVES FOR ALL PRESSURES

These Valves all have a 10″ opening



THE LUDLOW VALVE MFG. CO.



FIRE HYDRANTS

Genuine Ludlow Slide Gate, Frost Proof, Fire Hydrant. Rubber-faced Gate. Bronze Mounted.

(a) Simple in construction.

(b) Drip valve in extreme bottom of hydrant, draining hydrant barrel completely and permitting no water to remain in same.

(c) All working parts can be removed without disturbing hydrant barrel or doing any digging.

(d) Gate is released from seat before starting to rise, avoiding wear on gate rubber.

(e) Gate when shut remains tight when top of hydrant is removed.

(f) No flooding of street in case standpipe or barrel is broken.

(g) In opening hydrant, first turn of the stem closes the drip valve, after which the bronze wedge nut in back of gate is loosened, relieving gate from its seat.

Final turn of the stem after gate is closed and wedged opens the drip valve.

(h) Frost case unnecessary.

(i) Large waterway.

From Page 110 Ludlow Catalogue, 1910

Size of Hydrant or Diameter Valve Opening	2″	3″	4″	4½″	5″	6″	8″
Inside diam. of Stand Pipe	3″	4⅝″	5¾″	6¼″	7″	8″	10″
Size Bottom Connection	2″	3″ or 4″	4″ or 6″	6″	6″ or 8″	6″ or 8″	8″ or 10″
Number and Size Nozzles	1-2″	1-2½″	2-2½″	3-2½″	3-2½″	4-2½″	6-2½″

Steamer nozzle can be added on sizes 4″ and up, or can be substituted for 2½″ nozzles. Inside independent cut-off gate can be furnished on 2½″ nozzles if wanted.

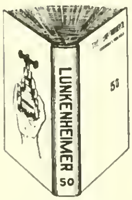
THE LUNKENHEIMER COMPANY

CINCINNATI, OHIO

BRASS, IRON, SEMI AND CAST STEEL VALVES, WHISTLES, COCKS, GAUGES, INJECTORS, LUBRICATORS, OIL PUMPS, OIL AND GREASE CUPS, MOTOR ACCESSORIES, ETC.

Adapted to the Requirements of All Classes of Machinery.

LUNKENHEIMER 1912 CATALOGUE



We illustrate on this and the three following pages only a few of our leading specialties, the whole being considerably condensed, owing to the lack of space. For a complete description, with sectional illustrations of the following, together with a large number of other engineering appliances, reference must be had to our 1912 CATALOGUE, a copy of which can be had free of charge.

This book consists of 654 PAGES, is handsomely bound and illustrated, and shows, describes and lists the ENTIRE LINE OF LUNKENHEIMER PRODUCTS, which is not only the LARGEST LINE OF HIGH GRADE ENGINEERING SPECIALTIES IN THE WORLD, but the VARIETY OF THESE APPLIANCES IS BY FAR THE GREATEST.

The LUNKENHEIMER 1912 CATALOGUE also contains tables and information of great value and of daily use to engineers in general,—in fact, it is a book that no engineer can afford to be without. Write for a copy.

LUNKENHEIMER REGRINDING VALVES

BRASS

Made in Globe, Angle and Cross Patterns; Screw or Flange Ends; Medium weight, for working pressures up to 200 pounds, Extra Heavy for 300 pounds; sizes ranging from 1/8 to 4 inches inclusive.

These valves can be reground quite a number of times, without removing them from their connecting pipes, making them as tight as when new. The discs and all other parts are renewable; the stuffing-boxes can be repacked under pressure when the valves are wide open; the areas through the bodies are in excess of the nominal inside diameter of the connecting pipes, and the union connection between the body and hub provides a non-corrosive, re-inforcing joint.

LEADING DIMENSIONS

Size of Valve	inches	1/8	1/4	3/8	1/2	3/4	1	1 1/4	1 1/2	2	2 1/2	3	3 1/2	4
Face to Face Screw End Globe Valve	Medium, "	1 19/32	2 1/32	2 1/8	2 7/16	2 15/16	3 11/32	3 7/8	4 5/16	5 1/4	6 7/16	7 3/16	8	9
	Ex. Hy., "	...	2 1/4	2 7/16	2 23/32	3 3/8	3 3/4	4 9/32	4 7/8	5 7/8	7 1/16	7 7/8	9	10 1/16
Face to Face Screw End Angle or Cross Valves	Medium, "	25/32	1	1	1 3/16	1 3/8	1 5/8	1 7/8	2 1/8	2 9/16	3 5/16	3 3/4	3 15/16	4 5/8
	Ex. Hy., "	...	1	1 3/16	1 9/32	1 9/16	1 13/16	2 3/32	2 3/8	2 11/16	3 17/32	4	4 1/2	5 1/32
Face to Face Flange End Globe valve	Medium, "	...	...	2 7/8	3 5/8	4 3/16	4 5/8	4 7/8	5 7/8	6 7/8	7 13/16	8 7/16	9 1/16	10 1/16
	Ex. Hy., "	...	...	3 1/4	3 7/8	4 1/2	4 3/4	5 1/4	6 3/8	7 3/8	8 9/16	9 3/8	9 13/16	10 3/4
Center to Face Flange End Angle or Cross Valve	Medium, "	...	...	1 21/32	1 21/32	2 1/4	2 17/32	2 13/16	3 3/32	3 5/8	4 3/16	4 15/32	5	5 9/32
	Ex. Hy., "	...	...	1 23/32	2 1/32	2 5/16	2 5/8	2 29/32	3 3/16	3 3/4	4 5/16	4 11/16	5 5/16	5 13/16
Center of Port to Top of Stem, when open	Medium, "	2 15/16	4	4	4 7/16	4 7/8	5 3/4	6 5/16	6 15/16	8 5/16	9 3/16	9 13/16	11 3/4	12 15/16
	Ex. Hy., "	...	4 3/16	4 3/16	4 11/16	5 7/16	6 3/8	6 15/16	7 3/4	9 1/8	10 1/4	11 1/16	12 3/4	14

THE LUNKENHEIMER COMPANY

LUNKENHEIMER BRASS "RENEWO" VALVES

Globe, Angle and Cross Patterns; Screw of Flange Ends; Medium weight, for working pressures up to 200 pounds, Extra Heavy for 300 pounds; sizes from ¼ to 3 inches inclusive.

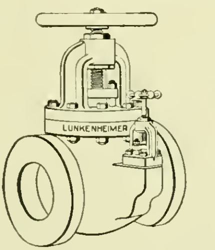
All parts are renewable, including the seat and disc, and the seating faces are also regrindable. Both seat and disc are made of a most durable nickel alloy, and their unique construction reduces the wear on the seating faces, caused by the great velocity of the steam flowing through the valve, makes them self-cleansing and eliminates water-hammer.

Areas through the bodies are larger than those of the connecting pipes; stuffing-boxes can be packed under pressure when the valves are wide open, and the valves are provided with a non-corrosive union connection between the body and hub.

LEADING DIMENSIONS

Size of valve	inches	¼	⅜	½	¾	1	1¼	1½	2	2½	3
Face to Face Screw End Globe Valves	Medium, inches	2 3/32	2 9/32	2⅝	3 7/32	3¾	4¼	4¾	5¾	6 13/16	7¾
	Ex Hy., inches	2 5/16	2 15/32	2⅞	3 17/32	4⅛	4 23/32	5¼	6⅜	7⅜	8⅜
Center of Port to Face of Screw End Angle Valves	Medium, inches	1	1 1/16	1¼	1 15/32	1 11/16	1 15/16	2 3/16	2⅝	3 5/16	3 13/16
	Ex Hy., inches	1 3/32	1 5/32	1⅜	1⅝	1 29/32	2 7/32	2 7/16	3	3 19/32	4⅛
Center of Port to Face of Screw End Cross Valves	Medium, inches	1	1 1/16	1¼	1 15/32	1 11/16	1 15/16	2 [illegible]/16	2⅝	3 9/16	4 1/16
	Ex Hy., inches	1 3/32	1 5/32	1⅜	1⅝	1 29/32	2 7/32	2 7/16	3⅜	3 13/16	4 5/16
Face to Face Flange End Globe Valves	Medium, inches	...	3	3 7/16	4	4 9/16	5 1/16	6⅛	7¼	8	9
	Ex Hy., inches	...	3¼	3 11/16	4⅜	5 1/16	5 9/16	6 13/16	8	9	10
Center of Port to Face of Flange End Angle or Cross Valves	Medium, inches	...	1 21/32	1 31/32	2¼	2 17/32	2 13/16	3 3/32	3⅝	4 3/16	4½
	Ex Hy., inches	...	1 23/32	2 1/32	2 5/16	2⅝	2 29/32	3 13/32	4	4½	5
Center of Port to Top of Stem, when open	Medium, inches	3⅞	3⅞	4 5/16	5 13/16	6 5/16	7	7⅝	8 11/16	9⅞	10 15/16
	Ex. Hy., inches	4 5/16	4 5/16	4¾	5 29/32	6¾	7⅝	8 11/32	9 17/32	11 1/16	12½

LUNKENHEIMER IRON BODY BRASS MOUNTED GLOBE, ANGLE AND CROSS VALVES



Medium Pattern, for working pressures up to 125 pounds, Heavy for 175 pounds and Extra Heavy for 250 pounds; Screw or Flange Ends. Extra Heavy Pattern can be had with or without interior or exterior by-pass. Medium and Heavy Patterns made in sizes from 2 to 12 inches inclusive; Extra Heavy without by-pass, from 2 to 10 inches, and with by-pass, from 3½ to 12 inches inclusive.

All parts subjected to wear are renewable; the seating faces of both the main and by-pass valves are regrindable, and the stuffing-boxes can be packed under pressure when valves are wide open.

For superheated steam, these valves can be had made of "Puddled" Semi-steel, a material having a tensile strength of 35,000 pounds per square inch; and for extreme conditions of pressure, superheat and strain, of cast Steel, the tensile strength of which is about 80,000 pounds per square inch.

LEADING DIMENSIONS

Size of Valve	inches	2	2½	3	3½	4	4½	5	6	7	8	10	12
Face to Face Screw End Globe Valves	Med & Hy., in.	6⅛	7 3/16	8 1/16	9	10	11⅛	12	13½	15¾	18	23¼	27
	Ex Hy., inches	8 3/16	10⅝	11¾	12¾	13	14	14⅞	16½	18¼	20	23¼	27¾
Center of Port to Face of Screw End Angle or Cross Valves	Med & Hy., in.	3 1/16	3 19/32	4 1/16	4½	5	5 9/16	6	6¾	7⅞	8⅝	10	11⅞
	Ex Hy., inches	4 3/32	5⅜	5⅞	6⅜	6½	7	7½	8¼	9⅛	10	11⅝	13⅞
Face to Face of Flange End Globe Valves	Medium, inches	7½	8½	9¼	10¼	11	12	12¾	14⅛	16⅛	19¼	24¼	27½
	Heavy, inches	8	9⅛	10	11	11⅝	12¾	13⅝	15	17	20¼	24¼	27½
	Ex. Hy., inches	9¾	11½	12½	13½	14	15	15¾	17½	19¼	21¾	25⅜	28⅝
Center to Face of Flange End Angle or Cross Valves	Medium, inches	3¾	4¼	4⅝	5⅛	5½	6	6⅜	7 1/16	8 1/16	8¾	10 [illegible]/8	12
	Heavy, inches	4⅜	5	5⅝	6 1/16	6⅝	6 15/16	7¼	8 1/16	9	9⅝	11¼	12¾
	Ex Hy., inches	4⅞	5¾	6¼	6¾	7	7½	7⅞	8¾	9⅝	10½	12¼	14
Center of Port to Top of Stem, when open	Medium, inches	9¼	10⅝	11½	13¼	14⅝	15⅝	17	18⅝	20¼	22½	26⅞	30½
	Heavy, inches	9¼	10⅝	11½	13¼	14⅝	15⅝	17	18⅝	20¼	22½	26⅞	30½
	Ex Hy., inches	13¼	14¾	16⅜	17¾	19½	20½	22	24	27¼	29⅞	35⅞	40¼
Center of Valve to End of By-pass, Extra Heavy Pattern	inches	...	...	...	7⅛	7¾	8	9¾	10⅞	11⅞	13⅛	16	17¾

(See also next page)

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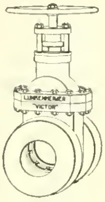
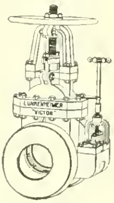
THE LUNKENHEIMER COMPANY

CINCINNATI, OHIO

LUNKENHEIMER IRON BODY BRASS MOUNTED "VICTOR" GATE VALVES





Made with either stationary stem inside screw, or rising stem and yoke; with or without by-pass, screw or flange ends.

Standard Pattern, sizes 2 to 24 inches. From 2 to 8 inches inclusive for working pressures below 125 pounds; above 8 inches for pressures up to 100 pounds. Medium Pattern for working pressures up to 125 pounds; without by-pass in sizes 2 to 24 inches; with by-pass, 5 to 24 inches. Heavy Pattern for 175 pounds working pressure; without by-pass, sizes 2 to 24 inches; with by-pass, 5 to 24 inches. Extra Heavy Pattern for pressures up to 250 pounds; without by-pass, sizes 1 1/2 to 16 inches; with by-pass, 5 to 16 inches.

All parts subjected to wear are renewable, and this includes the seats and discs. The valves are double-seated and will therefore take pressure from either end; both the main and by-pass valves can be packed under pressure when the valves are wide open, and the by-pass seating faces can be reground.

For superheated steam, the "Victor" Gate Valves are made of "Puddled" Semi-steel, and for extreme conditions of pressure, superheat and strain, they are made of Cast Steel.

LEADING DIMENSIONS

Size of Valve.................inches		1 1/2	2	2 1/2	3	3 1/2	4	4 1/2	5	6	7	8
Face to Face Screw Ends	Standard	...	4	4 1/2	4 7/8	5 3/8	6 1/8	6 1/2	6 7/8	7 5/8	8 1/4	9
	Med & Hy	...	4 1/2	5 3/16	5 7/16	5 11/16	6	6 3/16	7 5/16	7 7/8	9 3/4	10 3/8
	Ex Heavy	4 7/8	5 7/16	6 3/16	6 11/16	7 1/16	7 13/16	8 3/16	8 3/4	9 5/8	11 1/8	12 1/8
Face to Face Flange Ends	Standard	...	5	5 1/2	5 7/8	6 1/4	7 3/8	7 1/2	7 7/8	8 5/8	9 1/8	9 3/4
	Medium	...	5 1/4	5 11/16	6 1/8	6 1/2	7 1/8	7 1/2	8 15/16	9 1/2	10 7/8	11 3/4
	Heavy	...	6 5/8	7 5/8	8 1/2	8 5/8	9	9 5/8	10 1/4	10 7/8	12 1/8	13 1/8
	Ex. Heavy	5 3/4	6 5/8	7 5/8	8 1/2	9	9 5/8	10 3/8	12 3/4	13 1/2	15	16 1/2
Center of Port to Top of Stem, Stationary Stem Pattern..........	Standard	...	9 3/4	11 5/8	13 1/8	14 1/8	15 5/8	16 7/8	18 1/2	20 7/8	22 3/4	25 3/4
	Med & Hy	...	10	12 1/4	13 3/4	14 3/4	16 1/4	17 1/4	19	21	22 3/4	26
	Ex Heavy	10 1/4	12	13 3/4	14 3/4	16 1/2	18	19 1/4	20 3/4	23 3/4	25 1/2	28
Center of Port to Top of Stem, when open, Rising Stem & Yoke Pattern	Standard	...	12 7/8	15	16 5/8	19 3/8	21 1/4	23 1/4	25 3/4	30	33 3/4	38 1/4
	Med & Hy	...	13	15 3/4	17 1/2	20 3/4	23	24 3/4	27	31 1/4	35	39 1/4
	Ex Heavy	12 3/4	14 1/2	17	18 3/4	21	23 1/4	25	27 1/2	32 1/4	35 1/2	39 1/2
Center of Body to End of By-pass	Med & Hy	...	...	...	...	...	...	...	6 1/2	7 1/4	8	9
	Ex Heavy	...	...	...	...	...	...	...	9 1/4	10 1/2	11	12 1/4

Size of Valve.......................inches		9	10	12	14	15	16	18	20	22	24
Face to face Screw Ends.......	Standard	...	10 1/8	11 3/8	...	...	...	...	...	...	...
	Med & Hy	11 1/4	13	14 1/4	...	...	...	...	...	...	...
	Ex Heavy	...	14 3/4	16	...	...	...	...	...	...	...
Face to Face Flange Ends.....	Standard	...	10 3/4	11 3/4	13	13 1/2	14	16	17	18	19
	Medium	12 1/2	14 1/4	15	16 1/2	16 3/4	18 1/2	22	24	25	26
	Heavy	14	15 5/8	16 1/2	18	18 3/8	20 1/8	23 5/8	25 5/8	26 5/8	27 3/4
	Ex Heavy	...	19	19 3/4	21 1/4	22 1/2	24	...	...	...	...
Center of Port to Top of Stem, Stationary Stem Pattern.....	Standard	...	30	34 3/8	37 7/8	39 1/2	42	46 1/4	50 7/8	54 1/2	59
	Med & Hy	27 1/2	30	34 3/4	38	39 1/2	42	46 1/2	51 1/2	55	59 1/2
	Ex Heavy	...	32 1/2	37	40 1/2	42 1/2	45 1/2	...	...	...	...
Center of Port to Top of Stem, when open, Rising Stem & Yoke Pattern..............	Standard	...	46	51	61 1/2	65 1/4	69 1/2	75 5/8	83 7/16	91	98 1/4
	Med & Hy	...	47 1/2	55	62 1/2	66 1/2	71	77 1/2	85 1/2	93	101
	Ex Heavy	...	47 1/2	55	62 1/2	66 1/2	70 1/2	...	...	...	...
Center of Body to End of By-pass....................	Med & Hy	9 3/4	10 3/4	11 3/4	13 3/4	14 1/2	15	19 1/2	21 1/2	22 1/2	24
	Ex Heavy	...	14 1/2	15 3/4	17	18	19 1/4	...	...	...	...

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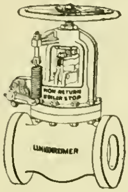
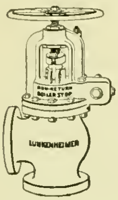
THE LUNKENHEIMER COMPANY

CINCINNATI, OHIO





LUNKENHEIMER NON-RETURN SAFETY BOILER STOP VALVES

Made in sizes from 4 to 10 inches inclusive, screw or flange ends, and in five different combinations of material to suit the requirements of various conditions of superheat and high pressure, and to meet the specifications of engineers who may differ as to what is best suited to the purpose.

Valves will immediately close in case of a sudden decrease in pressure on the boiler side of the disc, caused by the blowing out of a tube in the boiler or any rupture of the headers, shell, etc. Chattering or vibration of the disc is overcome by an ingenious outside spring arrangement. Valves cannot be opened by hand, but can be positively closed.

Of extra heavy construction, well made in every detail, and guaranteed in every particular. All parts subjected to wear are renewable.

LEADING DIMENSIONS

Size of Valve....inches	4	4½	5	6	7	8	10
Face to Face, Screw End Globe Valve....inches	13	14	14⅞	16½	18¼	20	23¼
Center to Face, Screw End Angle Valve....inches	6½	7	7½	8¼	9⅛	10	11⅝
Face to Face, Flange End Globe Valve....inches	14	15	15¾	17½	19¼	21¾	25⅜
Center to Face, Flange End Angle Valve....inches	7	7½	7⅞	8¾	9⅝	10½	12¼
Center of Body to Top of Stem, open: Globe Valve..inches	21¼	23	25	27	31¾	33½	40¾
Center of Body to Top of Stem, open: Angle Valve..inches	21	22¾	24¾	27	31	33	39½
Center of Body to Extreme End of Yoke....inches	9	9½	9⅞	11	12⅜	14	16½

LUNKENHEIMER "PUDDLED" SEMI-STEEL VALVES

Particularly adapted for high pressures and superheated steam.

The "Puddled" Semi-steel as used in Lunkenheimer valves is an extremely high-grade iron and steel alloy of very close grain and great strength, the tensile strength per square inch being about 35,000 pounds.

All parts subjected to wear are renewable, making the valves practically indestructible.

The line includes Globe, Angle, Cross, Gate, Check and Non-return Safety Boiler Stop Valves, guaranteed for working pressures up to 250 pounds per square inch, and to suit various conditions of superheat and meet the specifications of engineers who differ as to the material used for the trimmings, "Lunkenheimer "Puddled" Semi-steel Valves are made in two combinations.

LUNKENHEIMER CAST STEEL VALVES

For extreme conditions of pressure, superheat and strain, Lunkenheimer Cast Steel Valves are unexcelled.

They are the only cast steel valves that meet the specifications of the American Society for Testing Materials.

The tensile strength of Lunkenheimer Cast Steel is about 80,000 pounds per square inch, with a safe elastic limit and excellent elongation.

To suit the requirements of various conditions of superheat and high pressure, and also to meet the specifications of engineers who may differ as to what is best suited to the purpose, Lunkenheimer Cast Steel Valves are made in two combinations as regards the material used for the trimmings.

The line includes Globe, Angle, Gate, Non-return Boiler Stop Valves, etc.

THE NATIONAL AIR CELL COVERING CO.

210-218 VAN BRUNT ST., - - BROOKLYN, N. Y.

PYRO-BESTOS SECTIONAL STEAM PIPE COVERING

Pyro-bestos is an improved absolutely water and fire-proof heat-insulating material, and is distinguished from all other heat insulating materials from the fact that while other materials are more or less fire-proof none of them are water-proof.

In the form of a Sectional Removable Pipe Covering its superior fire-proof qualities and resistance to any deterioration from excessive heat marks it as especially adapted for use on all power house work, or *high pressure or super-heated steam piping anywhere.* The high heat temperatures have no effect whatever on the material, whereas on any piping carrying steam at more than 150 lbs. pressure, 85% Carbonate of Magnesia or any other of the Pipe Coverings now in use disintegrates and, becoming a powdery mass, lose their effectiveness as good heat non-conductors.

Owing to its water-proof qualities it is the most suitable Covering for insulating **steam piping out of doors,** or wherever **exposed to the weather,** for **piping underground or in damp places,** also for piping under the **floors of piers and docks, etc.,** as the occasional submersion in water, to which these pipes may be subjected to on account of tides, has no effect on Pyro-bestos.

Pyro-bestos Sectional Pipe Covering is furnished in 3-foot lengths and to fit any size pipe for ½″ to 30″ in diameter. Special Sectional Removable Coverings are furnished for flanges, owing to the necessity of getting at the flanges when desired, but for covering all other fittings we advise the use of our Pyro-bestos Cement Felting, as owing to the lack of uniform shape and measurements among fittings, it is impossible to make a satisfactory sectional Removable Covering for them.

Pyro-bestos is especially adapted for insulating street mains of Heating Stations or those from a Central Heating Plant.

PYRO-BESTOS AS A NON-CONDUCTING LINING FOR SMOKE FLUES, BREECHINGS, AND STEEL STACKS

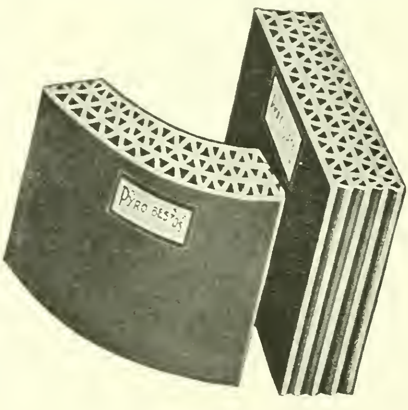
Pyro-bestos as a lining for steel smoke stacks occupies a special field of advantage, as by means of its use Architects are enabled to substitute the lighter weight and less expensive steel stack construction for the brick stack heretofore almost compulsory in its use.

Being fire-proof and water-proof and also, what is most important, absolute proof against the action of the gases of combustion, it not only protects the steel stack against all possibilities of wear, but also by reason of its superior non-conducting efficiency does away with all heat radiating from the stack.

It is easily applied to the interior of the stack by means of bolts and supporting angle iron rings spaced 36″ centers.

It has been the practice to erect in some cases steel stacks lined with brick, but in view of the ability to use Pyro-bestos lining in place of brick, the latter can be profitably dispensed with, as Pyro-bestos is not only a much cooler lining but also considerably lighter in weight.

Two inches thick Pyro-bestos lining, including the angle iron rings, weighs but about 30 pounds per square foot, or one-fourth that of a 5″ radial brick lining, and as it obstructs in any 6 or 7 foot diameter stack only 10% of the opening as against 30% for brick, a very large saving can be effected in the construction of the stack, as it can be less in diameter to provide proper draught and of lighter gauge construction and support to carry the weight of the lining.



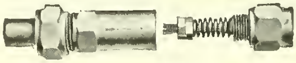
The best material for construction of fire-proof or non-conducting ceilings and partitions.

GREENE, TWEED & CO.

109 DUANE STREET, NEW YORK

MANUFACTURERS OF THE

ROCHESTER AUTOMATIC LUBRICATOR



Vacuum and Check Valve

The Lubricator, in the manufacture of which no expense has been spared, efficiency and high quality being our aim rather than low prices.

For the lubrication of the cylinders of all types of steam engines and pumps as well as air and ammonia compressors.

Made in all sizes from one-half pint to two gallon and with any number of feeds from one to eight. Also made with two compartments, for use where different kinds of oil are used in the different cylinders of the same machine, such as air compressors, ice machines, etc.

Finish-all sizes above one-half pint fully nickel-plated, one-half pint size, japanned body.

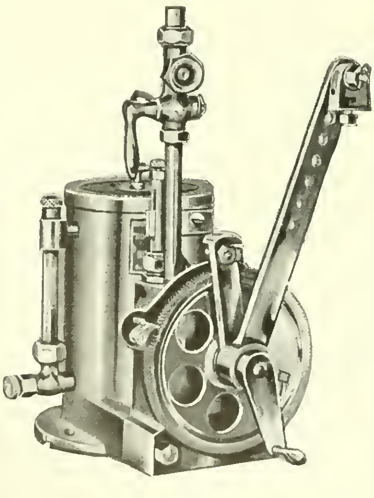
Working parts are made of steel, and all bearings are case hardened.

All the mechanism can be instantly detached and removed, giving easy access to the working parts for cleaning, repairing, etc., without disturbing the bowl or reservoir attached to the engine.

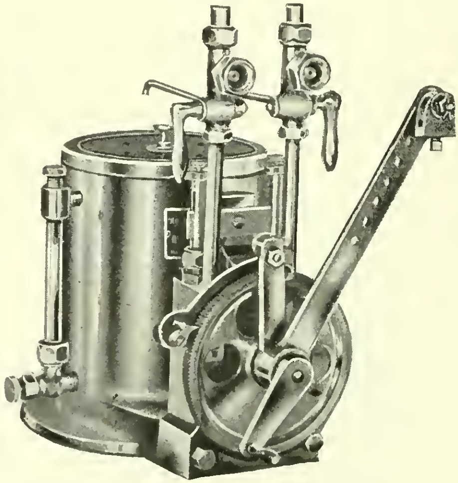
Equipped with Multiplus Sight Feeds, and vacuum and check valves.

Each feed is regulated independently.

Not affected by temperature, pressure or vacuum.



Single Feed



Double Feed

"PERFECT FORCE FEED LUBRICATION"

HILLS-McCANNA COMPANY

153 WEST KINZIE ST., CHICAGO, ILL.

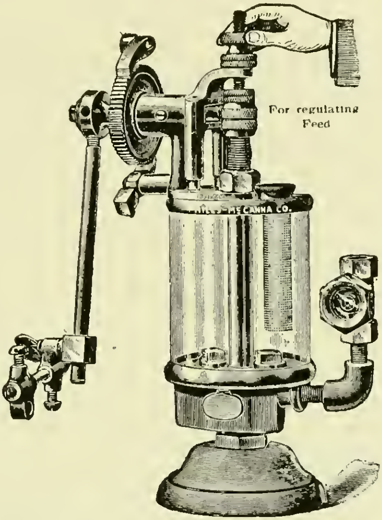
STEAM SPECIALTIES, FORCE FEED LUBRICATING PUMPS, HIGH-PRESSURE GAGE COCKS, SWING JOINTS FOR BEARINGS, LOW WATER ALARMS, METALLIC DISCS FOR VALVES

FORCE-FEED LUBRICATING OIL PUMPS

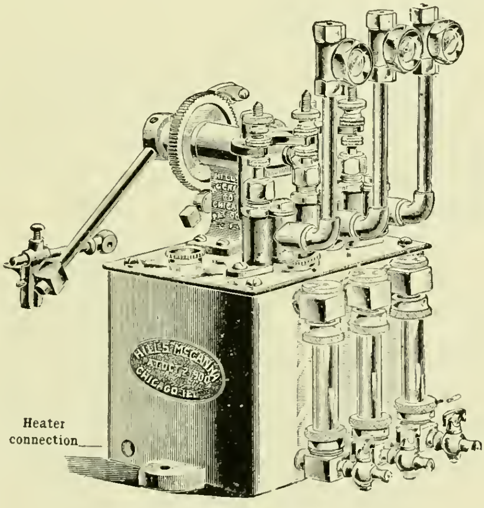
Our Oil Pumps have received the test of long use and varied applications, and have given thoroughly successful results.

The valves and operating motion are entirely outside of the Reservoir, and have a positive sightfeed, which can be regulated to any desired feed without stopping the pump.

Our pumps are made from one to any desired number of feeds.



Single Oil Pump with Glass Holder
One Pint and One Quart sizes only



Triple Oil Pump, as made from One to any number of feeds

APPLICATIONS

Hills-McCanna Force Feed Lubricating Pumps are illustrated in our catalog in successful service on

Elevator Pumps
Boiler Feed Pumps
Four-Valve Engines
High Speed Engines
Mine Motor Engines
Gas Engines
Steam Shovels
Steam Hammers

Price list and further information on request.

McCORD MANUFACTURING CO.

NEW YORK DETROIT CHICAGO

"McCORD" FORCE-FEED LUBRICATORS. "McKIM" GASKETS

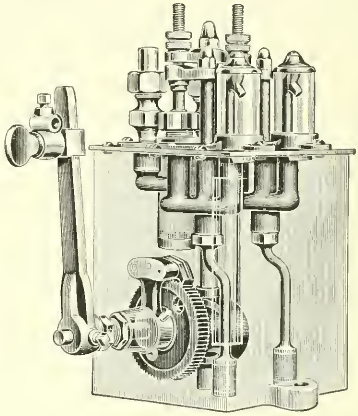
"McCORD" FORCE-FEED LUBRICATORS

Insure the positive delivery of just the right quantity of clean oil to just the right spot at just the right time—and in perfect synchronism with the engines or machines they are lubricating.

Interior mechanism is easily accessible; all working parts are of the best drop forged steel, case hardened, and are constantly running in oil, thus reducing wear to a minimum.

We guarantee each Lubricator perfect in every respect.

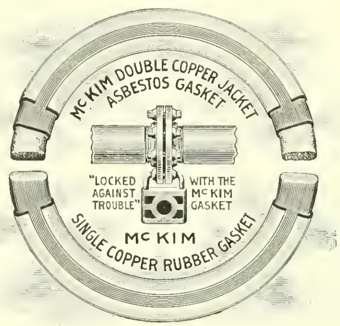
Write for Catalog "IL."



Class "B"

Number	1	2	3	4	5	6	7	8	9
Feeds—Number	1	2	1	2	3	1	2	3	4
Oil Capacity—Gallons	1/4	1/4	1/2	1/2	1/2	1	1	1	1

"McKIM" COPPER



GASKETS ASBESTOS

"McKim" Gaskets back up every claim we make for them. And we claim that they make joints tight and keep them tight for years; that they will withstand the highest pressure and superheat; that they will not spread or "blow out," and that they may be applied again and again.

They are made of a shell of purest Lake Superior Copper, specially treated, encasing a packing of Red Rubber or Asbestos—a combination impervious to heat, pressure, and chemical action of any circulation at a minimum tension of bolts and nuts. Made in all sizes and shapes and sold under a positive guarantee.

Save Time, Power, Labor

Send for free sample and foı Catalog "IG."

ALBANY LUBRICATING CO.

ADAM COOK'S SONS, Props.

708-710 WASHINGTON STREET

NEW YORK, N. Y.

ALBANY GREASE AND ALBANY GREASE CUPS FOR THE LUBRICATION OF ALL KINDS OF MACHINERY, ESPECIALLY LUBRICATION WITH INFREQUENT ATTENTION. ALBANY GREASE HAS BEEN ON THE MARKET FORTY-FOUR YEARS.

Insist on Getting Package with this Trade Mark

TEMPERATURE AND LUBRICATION

It is of prime importance in lubrication that grease of the proper consistency be used.

No good bearing lubricant can have the same viscosity in both winter and summer temperatures.

The melting point of a pure body lubricant, such as Albany Grease, varies slightly in the different seasons of the year.

If you expect to derive the utmost value from this King of Lubricants you should specify the proper consistency according to the season.

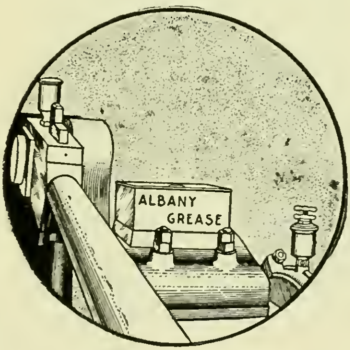
Take exposed journals in extremely cold weather, or slow-running journals under heavy pressure running in a cold room, you wouldn't expect to get the same results that you might in summer with the thermometer flirting with 90° in the shade.

In Albany Grease there are Soft Numbers (0 and 1) for cold and extreme cold weather. For moderate, warm and summer weather use No. 2 and No. 3.

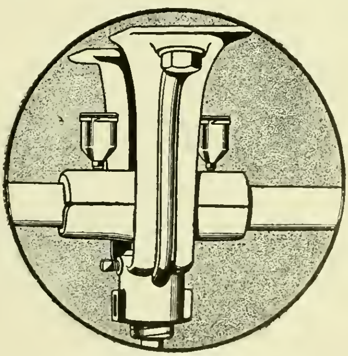
Albany Grease Nos. X, XX, or XXX have a "just right" consistency to adapt themselves to varying conditions of high or extreme temperatures.

The point is, there is an Albany Grease to meet *all* conditions.

The following illustrations show the adaptability and application of Albany Hand-made Cup on main bearing working in perfect harmony with Albany Spring Compression Grease Cup on eccentric and the Cast Spindle Grease Cup on crank pin. Also of the Albany Steel Funnel Cups on shafting feeding only when machinery is in motion. No drip or waste.



Albany Grease on Main Bearing



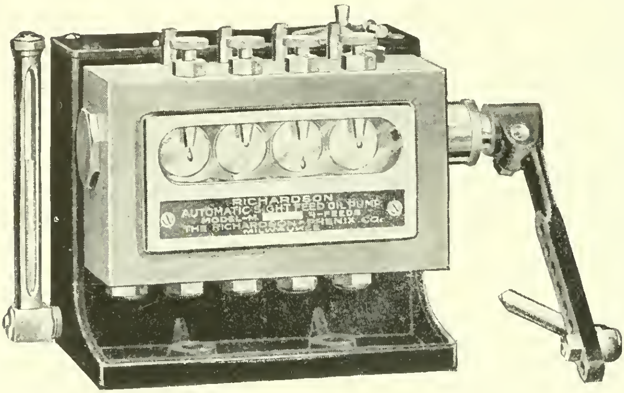
Albany Grease applied to Shafting

THE RICHARDSON-PHENIX CO.

126 RESERVOIR AVE., MILWAUKEE, WIS.

LUBRICATION ENGINEERS AND MANUFACTURERS

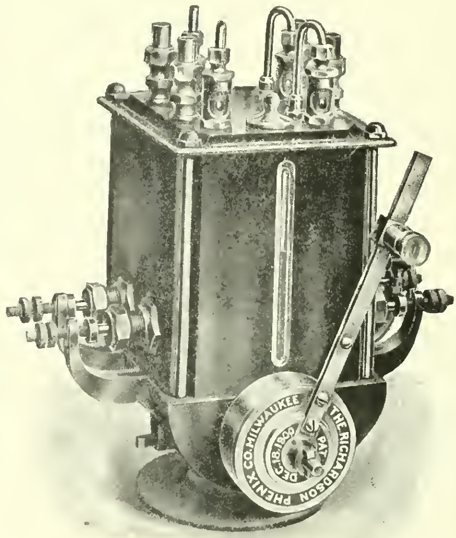
THE RICHARDSON SIGHT FEED LUBRICATOR



operates on a new principle in that it supplies oil for cylinder lubrication in small particles for every stroke of the engine piston. Built in sizes of from one to twenty-two feeds and if desired can be furnished subdivided to handle two or more kinds of oil. Fully illustrated and described in catalog No. A-53.

PHENIX LUBRICATOR OIL PUMPS

These lubricators are especially adapted to the libricating of high-speed engines, all power plant auxiliaries, steam hammers, dredges, hoisting and traction engines, etc. Built in sizes from one to twelve feeds, square type and one to two feeds, round type. Can be furnished with divided tanks if desired. Salient Features: Delivers oil against any pressure up to several thousand pounds—at any lever stroke from $\frac{1}{4}$ to 7 inches regardless of changes in temperature or viscosity of oil or length of feed line. Fully illustrated and described in catalog No. A-54.



THE GARLOCK PACKING COMPANY

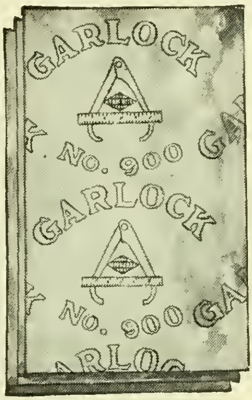
PALMYRA, N. Y.

New York	St. Louis	Denver	Pittsburgh	Philadelphia
Chicago	Cleveland	Boston	New Orleans	San Francisco

MANUFACTURERS OF FIBROUS AND METAL PACKINGS FOR EVERY CLASS OF SERVICE.

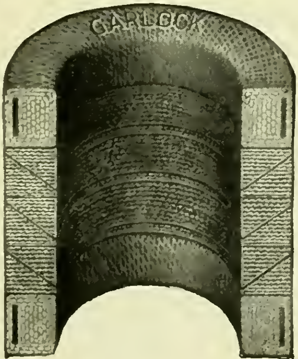
Style No. 200

Style No. 200 High Pressure Packing will give reliable and efficient service without injury to piston rods, because it is thoroughly lubricated throughout every fibre, and the material, design and workmanship are unequalled for use against high-pressure steam.



Style No. 900

Style No. 900 Sheet is not affected by any temperature up to 670° Fahrenheit, and has a tensile strength of more than 6000 pounds per square inch. It is adapted to steam, air, ammonia, acids, or any service where a sheet packing can be used—particularly desirable for superheated steam.



Style No. 446

Style No. 446 Duo for medium pressure is a combination of High-Pressure and Sectional Rings put up in sets to exactly fill stuffing box. The Sectional Rings adapt themselves automatically to rods not running true, while the High-Pressure Rings bear the brunt of the pressure and heat at bottom of stuffing box.

Garlock Packings are made in over two hundred styles and combinations to meet every known requirement. We will assume entire responsibility in selecting the proper styles or combinations of our packings to work successfully and economically under any stated conditions; and if goods are not wholly satisfactory to customer we will refund promptly the cost of same. A card will bring our catalog which fully illustrates and describes our various styles of packings.

GOETZE GASKET AND PACKING CO.

22 ALLEN AVE. NEW BRUNSWICK, N. J.

METAL GASKETS OF VARIOUS TYPES. METALLIC ENGINE PACKING. SHEET PACKING FOR FLANGES. VALVE GASKETS.

"DEVO" GASKETS

The latest Goetze product is the new DEVO Gasket for high pressure, superheated and saturated steam and other unusually severe conditions. This gasket is fully described in five words: Corrugated—Steel—Asbestos—Covered—Graphited.

It combines the great mechanical strength and everlasting durability of Goetze copper and asbestos gaskets, while at the same time it is sold at a much lower price. In fact, a price which compares favorably with inferior ga kets.

DEVO Gaskets appeal to every practical engineer because they are *absolutely indestructible* and the nearest approach to a *permanent* and *everlasting* gasket that has ever been attained.

OUR FIVE YEAR GUARANTEE

Every *Devo Gasket* is guaranteed for five years and will be replaced within that time if it fails to make good. Will make any pipe line *absolutely tight* and will never blow out.

SHIPPED ON 90 DAYS' TRIAL

And you need not pay for them if they fail to make good on every claim. We take the chances, not you.

Goetze's Elastic Corrugated Copper Gasket with Asbestos Lining No. 2, for flanges, makes a joint practically as leak-proof as the pipe itself, even with the roughest, most uneven surfaces.

GOETZE'S VALVE GASKETS

save trouble and money. They are for Valves of Jenkins Type and are made of copper and asbestos.

"GOETZERIT"

is a sheet packing for flanges made from pure, prime, asbestos fibre, compressed under an exceedingly high pressure and impregnated with a substance which makes it proof against the action of superheated and saturated steam, acids, ammonia, gas, alkaline products, etc. It is made in sheets approximately 39 inches by 39 inches of any desired thickness, and ready-made gaskets for standard and extra-heavy flanged fittings of from one inch to 24 inches in diameter are kept in stock. Price in sheets $1.00 per lb.

GOETZE GASKET AND PACKING CO.

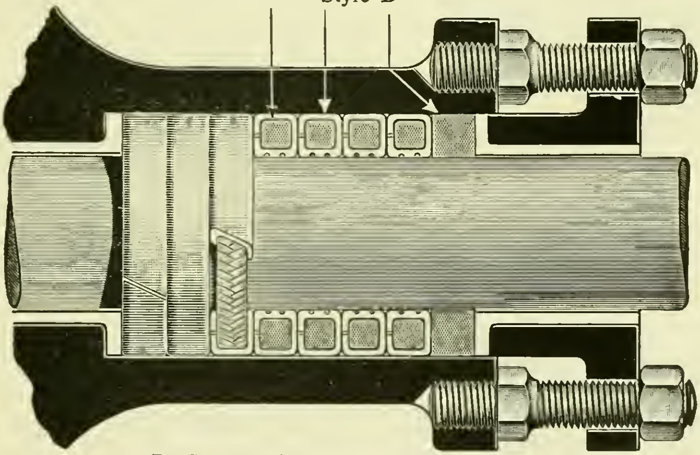
Goetze's Gaskets are a guarantee against frequent, costly shut-downs for packing renewals.

Price List

For Standard Flanged Fittings				For Extra Heavy Flanged Fittings		
Price per Goetze No. 2 Gasket	Price per Devo Gasket	Size of Gaskets in. × outs. dia. inches	Size of Pipe inches	Size of Gaskets in. × outs. dia. inches	Price per Devo Gasket	Price per Goetze No. 2 Gasket
.16	.13	1¼ x 2½	1	1¼ x 2⅞	.14	.18
.20	.16	1½ x 2¾	1¼	1½ x 3⅛	.21	.27
.24	.19	1¾ x 3	1½	1¾ x 3½	.24	.30
.32	.25	2¼ x 4	2	2¼ x 4¼	.29	.36
.40	.32	2¾ x 4¾	2½	2¾ x 5	.36	.45
.48	.38	3¼ x 5¼	3	3¼ x 5⅞	.43	.54
.56	.45	3¾ x 6¼	3½	3¾ x 6½	.50	.63
.64	.51	4¼ x 6⅝	4	4¼ x 7	.57	.72
.72	.57	4¾ x 6⅞	4½	4¾ x 7⅝	.65	.81
.80	.64	5¼ x 7⅝	5	5¼ x 8⅜	.72	.90
.96	.77	6¼ x 8⅝	6	6¼ x 9¾	.86	1.08
1.12	.89	7¼ x 9⅞	7	7¼ x 10⅞	1 —	1.26
1.28	1.02	8¼ x 10⅞	8	8¼ x 12	1.15	1.44
1.44	1.15	9¼ x 12⅜	9	9¼ x 13	1.29	1.62
1.60	1.28	10¼ x 13¼	10	10¼ x 14¼	1.40	1.80
1.92	1.35	12¼ x 16	12	12¼ x 16¾	1.73	2.16

GOETZE METALLIC PACKING

Style D



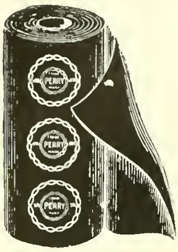
For Steam Engines, Pumps, Compressors, Etc.

WILL KEEP	Your PISTON rod perfectly smooth.
WILL LAST	For years, and that's how you will save a lot of worry and unnecessary work in repacking.
OUR GUARANTEE	Will be for three years, providing the piston rod is true and in good condition. Write us at once and we will be glad to send full particulars and price.

LA FAVORITE RUBBER MFG. CO.

PATERSON, N. J.

MANUFACTURERS OF PERRY SPECIALTIES, PACKING, GASKETS, VALVES, RUBBER GOODS, ETC.



Perry Sheet Packing

PERRY SHEET PACKING

Plain or Wire Inserted.

Made in rolls of about 200 lbs. each, $\frac{1}{32}$, $\frac{1}{16}$, $\frac{3}{32}$, $\frac{1}{8}$, $\frac{3}{16}$, $\frac{1}{4}$, $\frac{3}{8}$, $\frac{1}{2}$ inch.

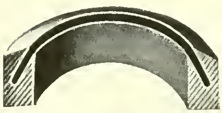
Perry Red Sheet is the old, pure, original and genuine *Red Sheet Steam Packing* brought out by Mr. Perry in 1886, and since perfected by him. We guarantee every ounce of it.

Perry Brown Sheet especially designed to resist extreme heat and high pressure.

Black Sheet Packing used with phenomenal success in the oil industry as an oil resisting packing. Equally good on alkali, acid or steam joints.

White Sheet Packing a good packing for general service. Similar to red.

"Armorplate" Sheet has stood 610° Fahr. and is most excellent for superheated joints.



Gauge Glass Washers

"MARVEL" GAUGE GLASS WASHERS

This cut illustrates the patented construction of "Marvel" Gauge Glass Washers by means of which they are automatically tightened by pressure from within the gauge glass. The greater the pressure the tighter the inner lip is held against the glass. Saves lots of trouble in the boiler room and many glasses.

Double Fold Gaskets

DOUBLE FOLD GASKETS

The Gasket is a combination of *Para Gum* and *Long Fiber Asbestos* constructed in such a manner as not to be affected by boiling water, high pressure steam, acid or oil.

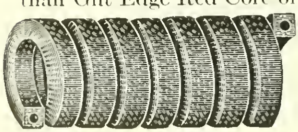
Being flexible and resilient it adjusts itself to any form, the *Double Fold* adding greatly to its strength, and when by our method it is inserted with brass wire, it is the *strongest, longest-lived* Gasket when taken care of and properly applied.

This cut shows a Double Fold Gasket after having been used five times to repack the same joint. The engineer was so well pleased he returned it of his own accord, that we might see it.

GILT EDGE PISTON PACKING

Made Round, Oval and Square.

There is no piston packing today more conscientiously made to give service than Gilt Edge Red Core or Plain Piston Packing.

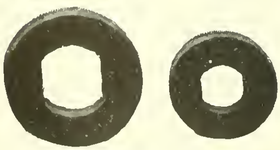


"Gilt Edge" Piston Packing

The fine lubrication used, the best long fibered duck and the rubber to create the cushion and bind it together make it as good as we know how to make it after 40 years of experience.

It is used in some high speed engines many months over a year, and as a Valve Stem Packing it cannot be improved.

We make any size piston packing for any service and pressure up to 5,000 lbs.



Semi-Metallic Valve Disc

SEMI-METALLIC VALVE DISCS

High Pressure, Radiator and Soft Rubber.

Our high pressure discs are used on superheat steam pipe lines with wonderful success—write for a sample to test, you will not use anything else.

We stock the sizes to fit Standard Valves.

Complete catalogue of Perry Products on Request.

SMOOTH-ON MANUFACTURING CO.

570-572-574 COMMUNIPAW AVENUE

JERSEY CITY, - NEW JERSEY

SMOOTH-ON IRON CEMENTS AND SMOOTH-ON CORRUGATED METAL GASKETS

"Trade Mark-Reg. U. S
Pat. Off."

SMOOTH-ON IRON CEMENTS No. 1 AND No. 2

These cements are chemical Iron Cements, prepared and sold in powder form for repairing leaks or breaks in castings and for making connections in steam or hydraulic work. They withstand fire, water, steam, oil and very high pressures. No. 1 is quick hardening. No. 2 is slow hardening and hydraulic. They must be applied to cold metal as a paste or putty. Expansion and contraction when hard, the same as cast iron.

SMOOTH-ON ELASTIC CEMENT No. 3

This is an Iron Cement, prepared and sold in paste form for use on all seams of boilers or tanks to stop leaks, for boiler patching and for screw-thread joints. Also for repairing very fine cracks. This cement is hardened by heat and is applied as a paint, paste or putty to hot or cold metal. Expansion and contraction when hard is the same as cast iron.

SMOOTH-ON CASTINGS No. 4

This is a chemical Iron Cement for repairing blemishes, blowholes or defects in iron or steel castings, having the same color and appearance. Made in powder form for use by foundrymen as a putty. Two grades, A and B.

SMOOTH-ON JOINTS No. 5

This is an Iron Caulking Cement for bell and spigot cast iron soil and greenhouse pipes to be used in place of or in combination with caulking lead.

SMOOTH-ON RIVET IRON CEMENT No. 6

This is a Metallic Cement for making water-tight joints on ship's sides; iron steel or wood, bridge work, construction work, metal skylights and vault lights' Withstands temperature changes and salt water. Prepared and sold in putty form.

SMOOTH-ON IRON CEMENT No. 7

This is a hydraulic Iron Cement, prepared and sold in powder form. For waterproofing concrete surfaces, brick surfaces, stopping leaks in concrete walls, floors, roofs and for bonding concrete. Apply alone or in combination with Portland cement.

SMOOTH-ON CORRUGATED METAL GASKETS

Smooth-On Gaskets are made from sheets of specially prepared metal, rolled with concentric corrugations and then coated with one application of Smooth-On Elastic Iron Cement. They are the best gaskets for flanged joints, for any pressure or temperature, for steam, water, fire, oil, air or ammonia.

Smooth-On Cements are sold only in tin packages.

THE METROPOLITAN COMPOUND MANUFACTURING CO.

367–373 FULTON ST., BROOKLYN, N. Y.

(Suite 501)

Telephone Main 3227

WATER PURIFYING CHEMICALS AND SPECIALTIES

CLEAN BOILERS

It is perfectly possible nowadays to keep boilers clean and in good condition at small cost, no matter what kind of feed water is used. Keeping Boilers clean (free from scale) prolongs their years of usefulness, and increases their efficiency.

When boilers are allowed to become foul (corroded or coated with scale), the amount of fuel required to maintain steam is greatly increased, and the possibility is always present of their bursting with disastrous results to life and property.

The increased amount of fuel required for varying amounts of boiler scale over that required when boilers are clean has been ascertained by Professors Warberton and Ashbridge to be as follows:

(The following tests were made by Profs. Warberton and Ashbridge.)

That	1–16	inch of scale causes a loss of over	20%	of fuel.
	¼	" " " " " " "	40%	" "
	½	" " " " " " " "	60%	" "

and more in proportion to the thickness and hardness of the scale.

From the standpoint of economy no further argument should be needed in favor of using every possible effort to prevent boiler scale and corrosion.

Another and even more vital reason is the ever present liability, when scale and corrosion exist, of an explosion with its attendant calamities,—death and destruction.

METROPOLITAN BOILER COMPOUNDS

Metropolitan Boiler Compounds are *purely vegetable*, containing no kerosene, soda, potash, acids or any other corrosive substances.

We do not claim that any one compound will meet every condition of boiler trouble, but on the contrary request in every case that we be allowed to analyze the feed-water or scale, and prescribe accordingly.

All of our compounds are prescribed after careful diagnosis of each case, and if used according to directions will clean out the scale from a boiler and *keep it clean*.

Correspondence solicited.

ALPHABETICAL INDEX TO CONDENSED CATALOGUES OF POWER PLANT EQUIPMENT

ALPHABETICAL INDEX TO DISPLAY ADVERTISEMENTS AND DIRECTORY CARDS

THE JOURNAL

of

THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS

JUNE 1912

35 CENTS A COPY $3 A YEAR

PAPERS FOR THE NEXT ANNUAL MEETING SHOULD BE ON HAND SEPTEMBER 1

THE SOCIETY OF THE INDUSTRIES

The American Society of Mechanical Engineers was organized to promote the Arts and Sciences connected with Engineering and Mechanical Construction. It has been doing this consistently for over thirty years, and its value in promoting the industrial progress of our country has come to be so great that it is now known as *the Society of the Industries.*

Engineers and those associated with them in conducting these industries should lend their aid to the work of the Society, and properly qualified men will be welcomed to its membership.

Members must be thirty years of age or over and have been so connected with engineering as to be competent as designers or constructors or to assume responsible charge of work in engineering, or must have engaged in engineering instruction for more than five years.

Associates must be thirty years of age or over and have been so connected with some branch of engineering or science, or the arts or industries, as to be qualified to coöperate with engineers in the advancement of professional knowledge.

Juniors must be not less than twenty-one and not over thirty years of age and have had such engineering experience as to be qualified to fill a responsible subordinate position in engineering work, or must have been graduated from a technical school of recognized standing.

A brochure has been prepared for the benefit of those who wish to become more familiar with the work of the Society, and will be forwarded upon request.

COMMITTEE ON INCREASE OF MEMBERSHIP

C. W. Aiken	J. P. Ilsley
R. S. Allyn	E. B. Katte
R. M. Dixon	H. S. Wynkoop
W. T. Donnelly	I. E. Moultrop, *Chmn.*

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THE JOURNAL

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THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS

VOL. 34 JUNE 1912 NUMBER 6

THE SPRING MEETING

The Spring Meeting in Cleveland, now in progress, promises to be one of the most interesting ever held by the Society, and both the Committee on Meetings and the local members in that city have made every provision for the pleasure and profit of the visitors. In addition to the excellent technical program which is offered, full advantage will be taken of the many attractions which the City of Cleveland has to offer. Its location upon the lake makes it a pleasant place to visit at this time of year and its industrial development gives the promise of technical excursions of unusual merit.

The meeting will open under favorable auspices, with an informal reception at the home of Mr. and Mrs. Ambrose Swasey. Especial provision will be made throughout the meeting for the pleasure and convenience of the visiting ladies, and both members and guests will be entertained at the Country Club on Wednesday afternoon. A reception and dance will be the social feature of Thursday evening, and luncheon will be served in the Chamber of Commerce on both Wednesday and Friday. Dr. Miller's lecture on Wednesday evening, on Sound Waves, will have many valuable and interesting features.

The arrangements for the reception of the visitors are in the hands of an Executive Committee of which Past-President Ambrose Swasey is Chairman.

INTERNATIONAL CONGRESS OF NAVIGATION

One of the most notable gatherings of engineers ever held in the United States is now in progress in Philadelphia, where the Twelfth International Congress of Navigation opened on May 23. Official representatives have been sent by thirty governments, chosen for their knowledge upon questions connected with the planning, construction and operation of works for the improvement of inland and maritime navigation. The Congress meets in the United States for the first time, upon invitation of the Government, with which the State of Pennsylvania has joined in making provision for the entertainment of the delegates. The Society is represented by Wm. T. Donnelly, of New York, Honorary Vice-President.

At the opening session on Thursday, President Taft, Governor Tener, Mayor Blankenburg of Philadelphia, Brigadier General Wm. H. Bixby, Mem. Am. Soc. M. E., Chief of Engineers, U. S. Army, and Prof. V. E. deTiminoff, acting president of the Association of Navigation Congresses, addressed the Congress. The work of the Congress proper began in the afternoon of the same day, when many questions bearing upon almost every phase of navigation engineering were taken up, among them the safeguarding of navigation and the prevention of marine disasters.

Trips of inspection and social events will occupy the time of the delegates until May 29, including trips to Trenton, to the South Bethlehem steel works and anthracite coal region, to Atlantic City and to Cape May. Arrangements have also been made for a party of the delegates to leave Philadelphia on June 3 for a tour of the Great Lakes, and members of the Society in attendance at the Spring Meeting have been especially invited to join this excursion upon its arrival in Cleveland on June 10, continuing to Detroit, Sault Ste. Marie, Milwaukee, and Gary, Ind. Those who may desire to participate are requested to communicate at once with Lieut. Col. J. C. Sanford, General Secretary, Twelfth International Congress of Navigation, Room 344, The Bourse, Philadelphia, Pa.

It is expected that many of the delegates will visit New York after the Congress has adjourned and a committee, consisting of

Charles Whiting Baker, Chairman, W. M. McFarland, H. deB. Parsons, George B. Massey, Stevenson Taylor, John W. Lieb, Jr., and Jesse M. Smith, has been appointed and has already extended to the delegates a cordial invitation to make use of the Society rooms during their stay. The City of New York has offered the use of one of the Municipal Ferries on Tuesday, May 28, for a tour of the city's waterways, going from the battery down the Narrows, up the East River to Hell Gate, and up the Hudson as far as Yonkers, thus affording a view of the docks, ferries, and other inland traffic arrangements. Luncheon will be served on board.

On account of the conflicting dates of the Spring Meeting of the Society, more formal entertainment of the delegates has unfortunately been impossible at this time. Their welfare, however, will be well cared for by the American Society of Civil Engineers who have planned a series of receptions and excursions. On June 6, an excursion to Albany on one of the Day Line steamers has been arranged and members of the Society are invited to participate. This trip will include stops at Interstate Palisade Park, where the "Half-Moon" will be on view, at West Point, either at Newburgh or Poughkeepsie where the "Clermont" may be seen, and will proceed from there direct to Albany. Those who desire may return the same evening by train. The cost will be the regular Day Line rates, $1 to West Point and return, and $2 to Albany one way.

LOCAL MEETINGS OF THE SOCIETY

No further meetings of the Society in Boston , New York, Philadelphia and St. Louis will be held until next September. The members living in Boston and its vicinity will coöperate, however, in a meeting of the American Institute of Electrical Engineers on Saturday, May 25, when the topic of Low-Pressure Turbines will be considered. In St. Louis the members will join with the Associated Engineering Societies of that city in a meeting under the auspices of the Engineers Club, on June 5, when Mr. A. Lee Moorshead, Associate Member of the American Society of Civil Engineers, structural engineer of the Erie Railroad, will give an illustrated lecture of the construction of the Bergen Hill Four-Track Tunnel Line at Jersey City, with which Mr. Moorshead has been personally connected.

HONORARY MEMBERSHIP CONFERRED ON DR. DIESEL

At a meeting of the Society held at the headquarters on the evening of April 30, Honorary Membership was conferred upon Dr. Rudolph Diesel of Bavaria. Dr. Humphreys, President of the Society, presided and called upon Col. E. D. Meier, Past-President and chairman of the committee of arrangements, to present Dr. Diesel for honorary membership.

Colonel Meier spoke of the debt of early civilization to the discovery of fire, which became an object of worship even among the most cultured peoples of the ancient world and said that the mechanical energy of heat through the medium of steam had been utilized more than two thousand years ago to open and close the massive doors of the Egyptian temples. Less than two centuries ago James Watt first applied the same power to the useful arts, and manufactures, means of transportation, mining, metallurgy, and the production of all things useful and beautiful increased a thousandfold. At first scarcely two per cent of the power locked in the fuel could be utilized. The genius of Woolf, Corliss and their followers increased this to six, eight, and finally nearly fourteen per cent. Beau de Rochas, Otto, Priestman, and other engineers, abandoning the intermediary steam, produced explosive engines in which the direct conversion of heat into power reached a useful effect of twenty per cent.

In 1897 after a persistent, patient, scientific effort of fifteen years, Rudolph Diesel presented to the engineering profession an internal-combustion engine in which controlled combustion replaced explosions, from which ignition troubles were banished and which reached twenty-eight per cent of efficiency, since gradually increased by further refinements in design to thirty-five per cent.

Based on careful search and investigations in independent lines, Lord Kelvin and the Imperial German Patent Court declared Diesel's process to be absolutely new. After ten years of successful practical demonstration in as many different countries and with a greater variety of fuels had proved his engine a great conserver of

the precious fire, the Royal Technical University of Munich conferred on Rudolph Diesel the dignity of the degree of Honorary Doctor of Engineering and the Technical Sciences, as "the inventor of the heat-motor which bears his name, the successful champion for the improvement of the working process of thermo-power engines, whose invention has advanced technical science and opened new avenues for the utilization of a widely disseminated fuel."

It is for these reasons that the Council of The American Society of Mechanical Engineers confers Honorary Membership on Dr. Diesel.

The certificate of membership was then formally presented to Dr. Diesel, who expressed his hearty thanks for the honor done him, and said that his work would never have grown to its present importance if he had not found in the United States, as in other countries of the world, industrial men and engineers who were not afraid to devote their material means and their scientific and technical knowledge to the development of ideas which they recognized to be right and to which they remained faithful amidst difficulties and prejudice. Dr. Diesel acknowledged gratefully Col. Meier's contribution to the development in America. The Diesel engine is not and can not be the work of one man only, but is the combined work of many. He expressed himself proud of a place among such names as Edison, Carnegie, DeLaval, Westinghouse, Isherwood and others who were Honorary Members of the Society.

An address upon the Development of the Diesel Engine was then made by Dr. Diesel, under the auspices of the Gas Power Section of the Society. This address appears in full in this issue of The Journal.

MEETING OF MASTER STEAM AND HOT WATER FITTERS

The members of the Sodiety have been cordially invited to attend the annual convention of the National Association of Master Steam and Hot Water Fitters, to be held at the St. Charles Hotel, Atlantic City, N. J., June 10-13. The Society recently coöperated with a committee of the association in formulating a schedule of standard weight and of extra heavy flanged fittings, published in the February issue of The Journal, which has been recommended to manufacturers for adoption.

MEETING OF THE COUNCIL

A regular meeting of the Council was held on Tuesday, May 14, President Humphreys presiding, at which the applications for membership recommended by the Committee on Membership were approved.

Desiring the assistance of the membership in the preparation of rules for the conduct of local meetings, the Council has invited each of the cities where meetings are now held, to send two representatives to a conference which will be held in Cleveland during the Spring Meeting, so that the views of all may be represented in the resolutions adopted. In consideration of this conference, action was deferred upon the requests received from St. Louis and San Francisco for the privilege of formulating geographical sections.

The report of W. H. Blauvelt and B. F. Wood, who represented the Society at the recent Conference on Patent Law held in Washington, was received and approved.

The report of the sub-committee on Constitution and By-Laws, giving the phraseology of the proposed amendments to the constitution, was received and approved, and these amendments ordered presented at the business meeting to be held in Cleveland.

The Council approved heartily of the work of the committee on reception to the delegates of the International Congress of Navigation, of which Charles Whiting Baker is chairman.

NEW PROCESSES FOR CHILLING AND HARDENING CAST IRON

By Thos. D. West

ABSTRACT OF PAPER

This paper outlines a series of experiments to determine the effect of different methods of treatment in chilling or hardening cast iron during the process of cooling after pouring the mold.

The first experiments showing how to produce mechanically mottled and white iron inside a gray body led to experiments with chillers used in different ways; and with various other heat-absorbing or hardening media, such as air, charcoal, powdered manganese, cyanide, etc. A study was made of the effectiveness of chillers of different thicknesses and of different metals; of the effect of cooling chillers, etc.

The experiments indicate, among other results, that the accepted idea of chilling occurring entirely while the molten iron is solidifying is wrong; and they show how stronger grades of iron can be used for car wheels, rolls, etc., and still obtain the desired depths of chill in such castings. They also demonstrate the superiority of air cooling over metal chillers.

NEW PROCESSES FOR CHILLING AND HARDENING CAST IRON

By Thos. D. West, Cleveland, Ohio

Member of the Society

Conditions are occasionally such that an "inside chill" is produced in castings, by which is meant that a casting with a gray or soft exterior may have the interior, or portions of it, composed of a hard, white or chilled iron, as shown in Figs. 2, 3, 9 and 10.

2 While inside chilling is claimed to be produced by hydraulic pressure, this is not the inside chill which has puzzled foundrymen, and prior to the mechanical creation of inside chill by the author, no one, as far as he knows, has explained how it could be produced at will. The discovery of how this can be done is due largely to experiments which the author has been conducting during the past two years with a view to overcoming the defects now existing in chilled car wheels, and this investigation led to other lines of research, as will be seen herein.

3 Most of the experiments were made at The West Steel Casting Company, Cleveland, Ohio. This company makes castings by the converter and crucible methods, the former requiring a cupola similar to that used in iron founding, and so permitting the casting of chillable metals. The irons used were approximately of the following composition: Carbon 2.75 to 3.25; silicon 1.75 to 2.00; sulphur around 0.06; manganese and phosphor each about 0.04. In cases where a more chillable metal was desired, small portions of stick or powdered sulphur were dropped on top of the molten metal when in the hand ladle.

4 In Fig. 1 is illustrated the experiment that created mechanically an inside chill. This gives views of the mold used in casting test specimens in open sand of the size seen in Fig. 5. The bar *A* was cast

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against a chiller block as at *E*, while bars *B*, *C* and *D* were surrounded with rammed sand. The bars having been poured, the gate connections *F*, *G*, *H* and *I* were broken and the sand around *C* and *D* removed as soon as their solidification would permit. When it was thought *C* and *D* would stand the pressure of tongs, they were lifted quickly and *C* was doused into a pail of water, while *D* was broken by an assistant to display conditions of its interior. The immersed bar *C* having cooled to a dark color, it was taken from the water and broken, and displayed an inside chill, such as is seen at *E′*,

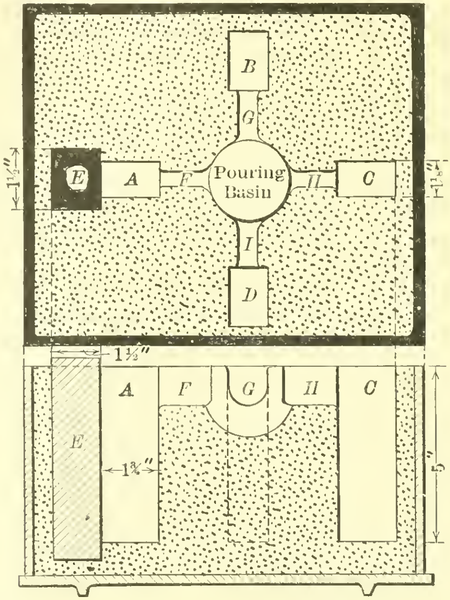


Fig. 1 Mold for Test Bars that Solved Inside Chill Problem

Fig. 9. The bar *D* showed an interior condition bordering on semi-molten metal. The chilled bar *A* showed that the chiller *E* had chilled the surface of *A* about ½ in. deep, while the bar *B* had a nice gray fracture. Bars *A* and *B* were not removed from their molds until nearly cold.

5 The philosophy of mechanically creating an inside chill exists in the outside body of a casting cooling slowly enough to allow the carbon to take a graphitic form, while the inner body, which is not wholly solidified, is cooled so rapidly that the carbon is held in the combined form, similar to the way it is held in the molten metal.

The graphitic state of the carbon in the solidified body causes the iron to be gray and soft, while the combined state causes it to be hard and white, or chilled.

6 The ability to create an inside chill by strictly physical manipulation led to the belief that it might be practicable to increase the depth of a chill beyond what present chillers can do, with like irons. Especially was this thought practicable for such castings as chilled car wheels and rolls. Several methods were devised for testing purposes, but finally those in Figs. 4, 7, 8, 13 and 14 were adopted for the chief researches. These devices admitted of a wide range for experiments and as a rule led to satisfactory results.

VARIABLE CONDITIONS AFFECTING CHILLING

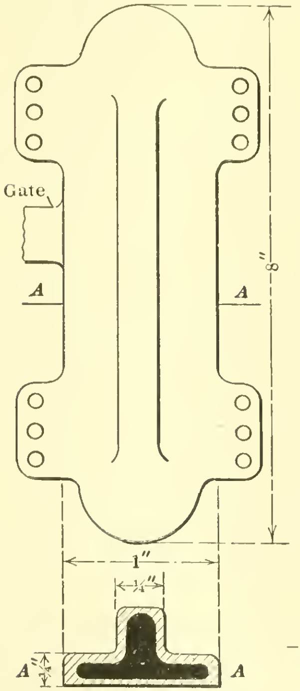
7 As many who are interested in founding are not cognizant of what is involved in the chilling of cast iron, the following recital is given of actions that take place and of conditions that exist in the process of chilling:

- *a* Iron is chilled prior to any formation of graphite. A chill may be made harder by continuing to cool it while the adjoining metal is still in a semi-molten state or very hot; as by this action any backward annealing to soften the chill is more or less retarded.
- *b* Under like conditions, the lower the silicon and the higher the sulphur and carbon, the deeper the chill.
- *c* Under like conditions, the chill will be deeper the smaller the area of the cross-section to be chilled.
- *d* Under like conditions the less the thickness in the chiller below what can be utilized, the less the chill in the casting.
- *e* The longer the casting remains in close contact with its chiller while its metal is in a chillable state, the deeper the chill.
- *f* The more fluid or the hotter the metal used in pouring a chiller mold, all other conditions being the same, the deeper the chill, from $\frac{1}{8}$ in. to possibly $\frac{3}{8}$ in.; and the greater the chillable nature of the metal, the more pronounced this effect.
- *g* Not all grades of cast iron are chillable. It requires, as a rule, for iron of a general carbon, less than 2 per cent of silicon and above 0.06 per cent of sulphur.

h On account of the variable percentages of silicon, sulphur and carbon required to produce chilled castings, ranging from 1.75 down to 0.50 for silicon, from 0.10 down to 0.05 for sulphur, and from 4.00 down to 2.50 for carbon, it can be seen that there must be what are commonly called "grades" in chillable irons.

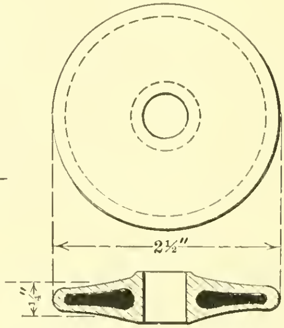
MOLD FOR MAKING COMPARATIVE CHILLING TESTS

8 In order to make comparative tests, a twin-chiller mold was



Shaded lines gray or soft iron

Fig. 2



Black, white or chilled iron

Fig. 3

Castings with Gray Exterior and Chilled Interior

designed, shown in Figs. 4, 7 and 8. By having the two molds combined so that they could be poured from the same basin, it was possible to make all the conditions alike in both, except the one which it was desired should vary for the particular test under way. The mold was further designed to produce conditions similar to those

existing when casting chilled car wheels and rolls. In making these latter castings the contraction of the chilled crust and the expansion of the chiller create a space between the exterior body of the casting and the interior face of the chiller. The ability to create a space as above in this experimental mold and to apply a heat-absorbing element to it in connection with other actions or treatment referred to later on, made it possible to conduct a large number of very satisfactory comparative tests.

9 In order to obtain a variable action so far as the chillers *P*, Fig. 4, were concerned, the braces *M* were removed and the wedges *N* driven down. If it were desired to have the space *K* in both molds, two persons were employed to work in unison at their respective ends. The wedges *N* would not be knocked down until the metal filling the mold showed evidence at the top edge of the bars of having solidified sufficiently to produce a self-sustaining crust. It was rather remarkable in the air-cooling tests, to be described later on, how clearly the rate of cooling and inner solidification could be judged by the changing color of the hot metal at the top edge of the bars next the chillers.

10 In casting bars intended to be kept in close contact with their chillers, either the runners connecting the pouring basin with the mold must be broken as soon as the metal in them has solidified sufficiently to permit such action; or care must be taken when pouring the molds not to fill them any higher than the level of the bottom of the pouring runners. By these means the disturbing influence due to the contraction of the runners and pouring basin is avoided.

11 Fig. 5 shows the form and size of the pattern used for molding the bars, while Fig. 6 is that of the manipulative chiller *P* employed in these tests. Each of these chillers weighs 3 lb. 14 oz. and the bars made from the pattern, Fig. 5, averaged 3 lb. and 4 oz. As Figs. 7 and 8 show devices for other purposes than those displayed in Fig. 4, comments on them are deferred.

FIRST EXPERIMENTS FOR DISCOVERING VALUE OF HARDENING MATERIALS

12 In starting to use the twin-chiller molds shown in Figs. 4, 7, and 8, the first manipulation was to draw back the chiller *P* of one mold about $\frac{1}{4}$ in. from the face of its bar casting as soon as the latter had solidified sufficiently to have a self-supporting crust facing the chiller, while the companion bar was left in close contact with its chiller until of a dark color (see Fig. 4).

13 In various tests a $\frac{1}{4}$ in. space K, Fig. 4, was formed by moving back the chiller, and the effect tried of quickly packing different materials into this space upon the backward movement of the chiller. The materials tried at different times were fine sand, coke dust, charcoal, powdered manganese, bone dust, hardening powder and poisonous cyanide. These tests were made with a view to determining whether such filling of the space would increase the depth of chilling in a bar, or cause it to be any harder than when the chiller remained in close contact with the bar until the latter was nearly cold.

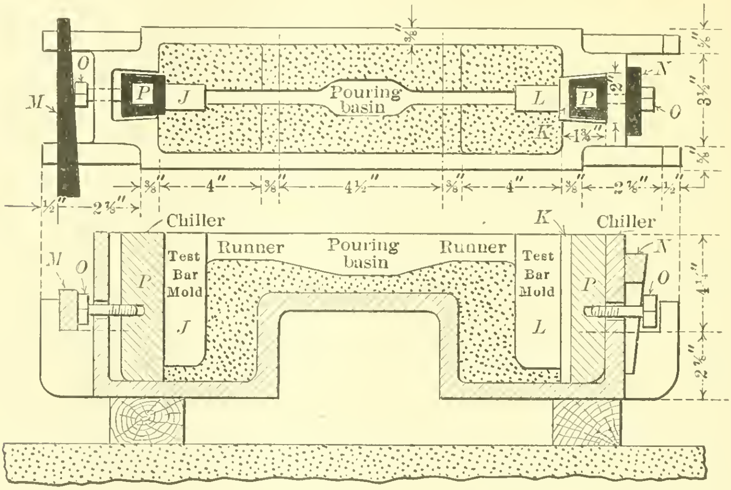


FIG. 4 MOLD FOR MAKING CHILLED TWIN SPECIMENS FOR FRACTURE TESTS

14 No noticeable effects were produced by the use of these intended hardeners. The thickness of chill of the bars kept in close contact with their chillers exceeded that of the treated bars by from $\frac{1}{4}$ to $\frac{3}{8}$ in. This was to be expected, as the withdrawal of the chillers P to create a packing space broke the contact of the chillers with their bars at the crucial moment, so far as their effectiveness was concerned in increasing the depth of the chill.

SECOND EXPERIMENT FOR DISCOVERING VALUE OF HARDENING MATERIALS

15 In this series of tests, both chillers were pulled back at the same moment to create spaces adjacent to both bars, as at K, Fig. 4. The tests were to discover if any greater depth of chill or hardening

was produced by packing one of the spaces quickly with the materials used in the first experiments while the other space was left open. The series showed the chill to be from $\frac{1}{16}$ in. to $\frac{1}{8}$ in. deeper in several of the treated bars than in the non-treated bars.

16 Tests for hardness, except for the cyanide, showed a gain of 6 to 10 per cent by the scleroscope. One cyanide test with companion all-chilled bars averaged 68 for the treated and 70 for the non-treated; while with another set of companion bars which were not chilled the non-treated bar gave 58 and the treated bar 50 on an average. This softening action of the cyanide may have been due to the fact that the bars were not cooled in water after treatment, as is necessary when case-hardening steel with cyanide. A

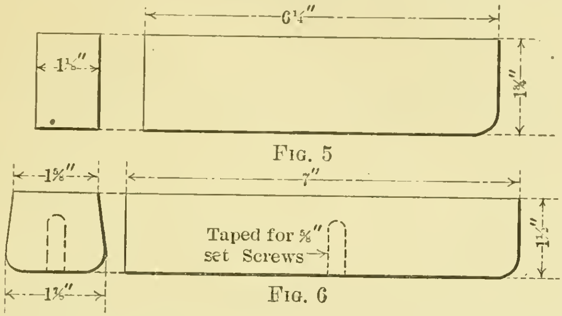


Fig. 5 Fracture Test Bar Pattern; Fig. 6 Manipulative Chiller

peculiar effect of the cyanide is to produce a denser and a finer crystallization of the treated chilled face about $\frac{1}{8}$ in. thick.

IMMERSION EXPERIMENTS

17 For this series, open sand molds of the plan shown in Fig. 1 were used, and by the aid of an assistant, two of the four bars were removed as soon as the crust solidification permitted. One of these bars was immersed and moved around in a pan of mud, which in some tests had salt mixed with it, while the second bar was simultaneously submerged in a pail of water. These tests were duplicated by having the pan nearly filled with a high fire-test oil in place of the mud.

18 Tests made by the second use of the open sand mold, Fig. 1, showed that the mud or oil cooling had little or no effect in chilling, on the average, while the water cooling was radical in its action. A', B', C', and D', Fig. 9, give a fair illustration of these tests. A' is the chiller-cooled bar; D' the all-sand one; C' the mud-cooled bar

and D' the one placed in water. Bars A' and D' were both left in their molds to cool naturally.

19 The bar D' displayed an inside chill as seen by the white appearance at D' and the gray corners and surface indicated by M'. The best sample of this effect, which was closely duplicated in several tests, is seen at E' in connection with the chiller-cooled companion bar F', which latter was cast against the face of the chiller E, Fig. 1, the same as bar A' in Fig. 9. The bar F' showed that a harder grade of iron was used than for A'.

20 The writer's experience in producing this inside chill mechanically, demonstrates it to be a sensitive process partaking of numerous forms, yet all verifying its practicability.

21 It is not improbable that castings, or sections of them, will eventually be produced in a regular manner for commercial use, having a gray or mottled exterior crust, while the adjoining or interior body of metal will be of a mottled, chilled or white iron. The writer can conceive of castings in which this combination of hardness might prove useful, but as his ideas might be considered visionary, he refrains from mentioning them.

TABLE 1 SCLEROSCOPE TESTS FOR HARDNESS *

Set Number of Tests	Set 1	Set 2	Set 3
Average of air-cooled chilled bars	56	65	61
Average of natural-cooled chilled bars	48	58	53
Average of increase in hardness effected	8	7	8

*The writer is under obligations to the kindness of Mr. Walter D. Sayle, president of the Cleveland Punch & Shear Works, Cleveland O., for the scleroscope tests given herein.

HARDENING A CHILLED BODY WHEN HOT BY IMPINGEMENT OF AIR AGAINST ITS SURFACE

22 Special attention was paid in this series of tests to the hardening effect of air applied directly to the hot chilled face of a bar. For tests of this character it is essential that the depth of chill in the comparative bars be of the same thickness. This condition was obtained by admitting the air to the treated bar only after it was thought the inner metal had all solidified, so that it could not be held responsible for any variation of depth of chill in the treated bars. Only three specimens of this series were tested by the scleroscope, as given in Table 1; but from filing and grinding tests made as a check on the results it is evident that a chill's hardness can be very materially increased by applying air, etc., as herein described.

23 Tests of the gray sides of the chilled bars for the second and third sets in Table 1 gave 52 and 42 respectively, showing them to average 25.4 softer than the chilled sides which had received the air treatment.

EFFECT OF AIR SATURATED WITH WATER

24 This series was conducted with a view to learning whether air saturated with water might be more effective than air alone in creating a chill, or in hardening. There was some difficulty at the start in obtaining satisfactory saturation, but this was finally secured by the use of a device which made it possible to vary the proportion of air or water as desired.

25 The series was instructive in demonstrating that so far as the chilling was concerned there was little to be gained by the saturated air, or what was gained would be secured by the use of a greater volume of air alone, so that the water could be dispensed with. This is not, however, to belittle the effectiveness of saturated air as a hardening medium, for among the tests in which saturated air was strongly applied, one gave 70 for the treated bar, and 52 for the non-treated bar, a gain of 34.6 per cent due to hardening.

SOFTENING EFFECT OF ANNEALING CHILLED IRON

26 Specimens of this series of tests were cast in the twin-chiller mold, as arranged in Fig. 8, without applying any air cooling to either chillers. This gave the same depth of chill in both bars. Several sets were cast and annealed, but only one set was tested by the scleroscope. Other sets showed by filing and grinding that they checked closely with those tested by the scleroscope. The annealing was done as follows: The bars were taken out of their mold together and one left in the open air, of about 70 deg. fahr., while the other was laid on the bottom of a hot crucible furnace, the oil fire having been shut off, and left there about twelve hours.

27 The chilled side of the unannealed bar tested at 68 and the gray side at 45. The chilled side of the annealed bar tested at 47 and the gray side 35. This gave a difference for the chilled sides of 21 and for the gray sides of 10.

RELATIVE EFFICIENCY OF WARM AND COLD CHILLERS

28 In order to be assured of correctness in his researches, the author undertook to determine the efficiency of different metals, and of different thicknesses of metal, for chillers and the relative efficiency of warm and cold chillers.

29 To determine the latter two chillers, both alike, were used, one of which was heated to various temperatures, from one bearable to the hand to one that would burn the flesh, while the other chiller was kept at the temperature of the atmosphere. The first three sets of these tests were made on a day when the thermometer registered 62 deg., and the second set of four tests when it was 55 deg.

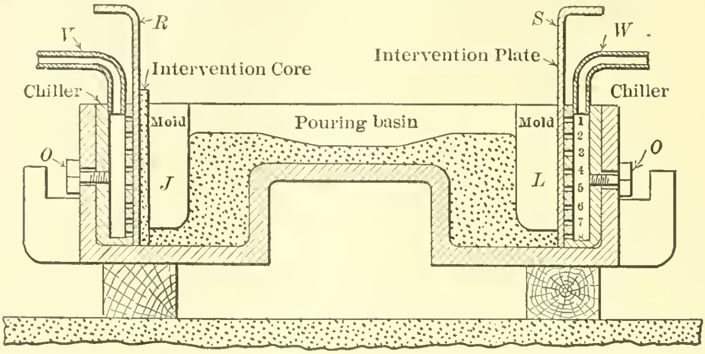


Fig. 7 Intervention Plate System for Air Cooling and Chilling of Molten Metal

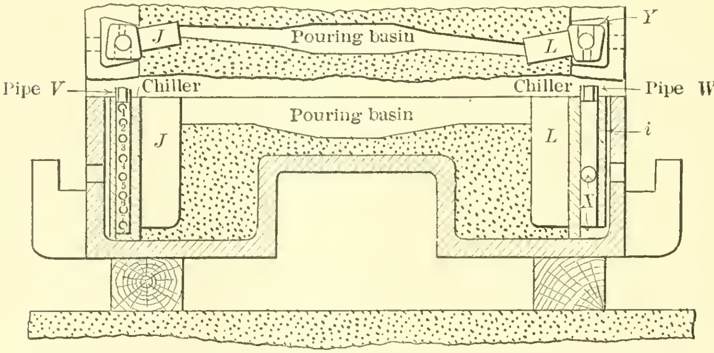


Fig. 8 Chiller Mold for Testing Chilling Effect on Castings by Cooling Chiller

The tests showed from $\frac{1}{16}$ in. to $\frac{3}{16}$ in. greater depth of chill in the bars having the cold chiller than those having the heated ones. Having recently read the claim that a warm chiller would chill deeper than a cold one, it was thought necessary to learn whether such was a fact, as it is unreasonable to expect such a result.

EFFICIENCY OF DIFFERENT THICKNESSES FOR CHILLERS

30 To determine the effect of different thicknesses for chillers,

tests were made by the writer at the Cleveland branch of the National Car Wheel Company, as well as at the foundry of The West Steel Casting Company. For this series open sand molds were used, as seen in Fig. 11. The chillers as shown were respectively $\frac{1}{4}$ in., $\frac{1}{2}$ in., $\frac{3}{4}$ in., 1 in., 2 in. and 3 in. thick; and all 2 in. wide by 9 in. deep.

31 The test specimens cast against these chillers in the wheel foundry were $1\frac{7}{8}$ in. by $2\frac{1}{2}$ in. and 8 in. long, and at the steel foundry, because of having a less chilling metal, they were of the size shown in Fig. 5. The top row of fracture views, Nos. 1 to 6, Fig. 10, is a fair representation of results obtained. The thickness of chill in the samples shown in Fig. 10 is approximately as marked. A study of these samples demonstrates that the efficiency of chillers in general use is far from being in accord with their thickness. The 3-in. chiller, for example, produced but $\frac{3}{16}$ in. more depth of chill than the 1-in. chiller.

32 Aside from their value in other ways, these tests suggest the advisability of makers of chilled rolls, car wheels, etc., trying steel metal chillers in place of the much heavier cast-iron ones. Steel chillers need be made only of the thickness required for efficiency in cooling and would still be strong enough to resist the contraction and expansion strains to which chillers are subjected. There is a liability of difficulty being encountered in using steel chillers on account of the steel warping through repeated heating. By using ribs or giving a special form to steel chillers this objection may be greatly reduced, if not wholly overcome.

EFFICIENCY OF DIFFERENT METALS FOR CHILLERS

33 It was important, at least to the writer, to know whether any difference existed in the efficiency of chillers of gray, white or all-chilled cast iron or of steel or wrought iron. Tests were made with these different metals at both foundries. Two sets of chillers were used, one 2 in. square and the other 1 in. by 2 in., all close to 9 in. long. Aside from grinding one face of these chillers to remove the scale and make them smooth, as with all other chillers used in the experiments of this paper, they were chipped or ground at their lower ends if needed, to make them all of the same weight. The plan of the open sand mold used is shown in Fig. 12. The test bar patterns were of the same size as used for the tests of Fig. 11, about four sets being cast from each size of pattern. While slight differences in the thicknesses of the chills resulting from chillers of the different materials seemed to indicate that one or another of the

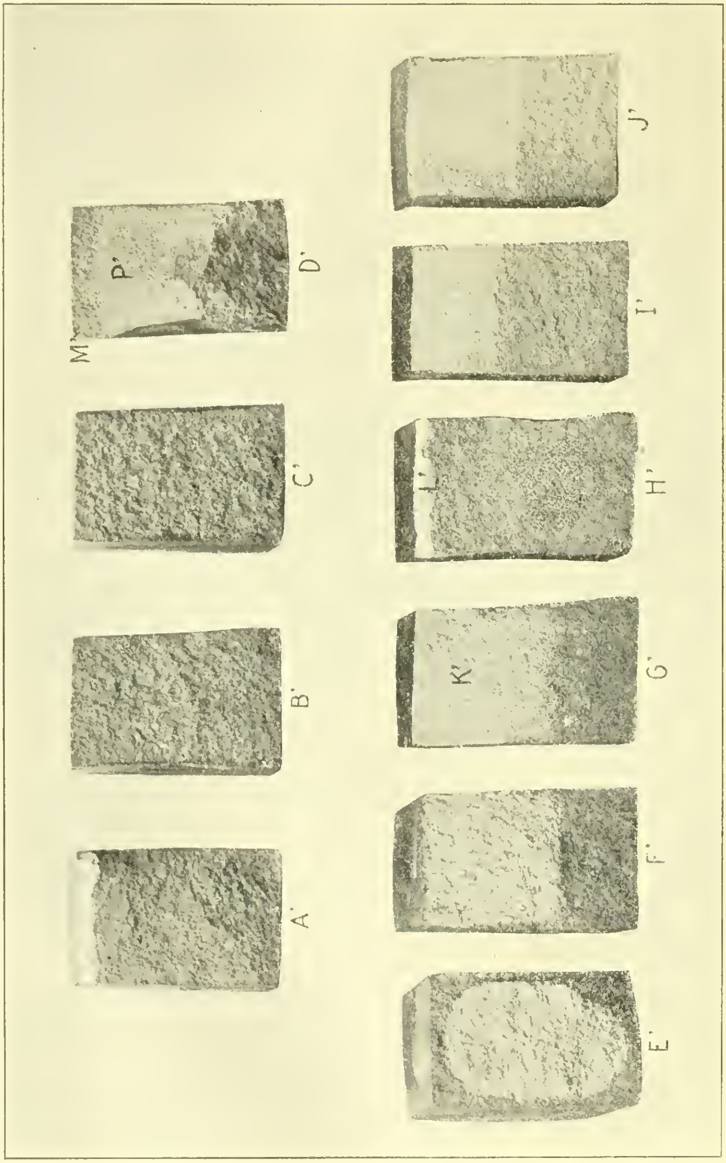


Fig. 9 Samples of Test Bars. Upper Row shows Results of Immersion Experiments. In the Lower Row *E'* shows an Inside Chill, *F'* a Chiller-Cooled Bar and the Rest illustrate the Superiority of Air Chilling over Metal Chillers

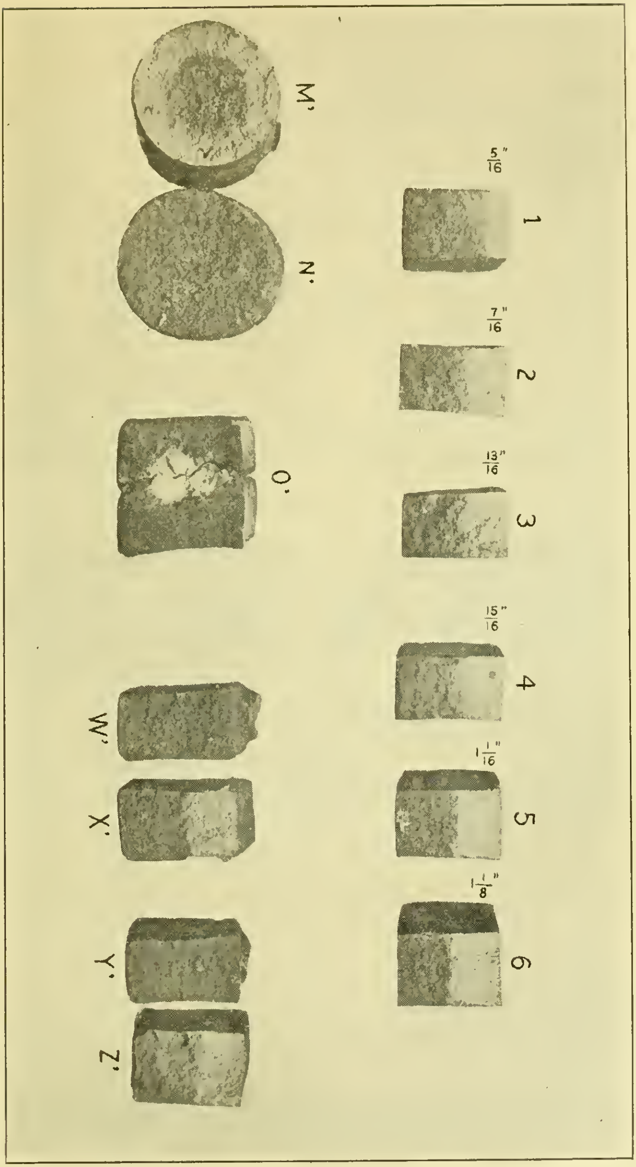


FIG. 10 SAMPLES OF TEST BARS. UPPER ROW ILLUSTRATES EFFICIENCY OF CHILLERS OF DIFFERENT THICKNESSES; LOWER ROW, RESULTS WITH SAND-FACED MOLD AND AIR-COOLED BARS CONTAINING VANADIUM AND TITANIUM

materials produced the deepest chill, there was so little practical difference in the results, taking an average of all the tests, that none of the chillers could be rated as being decidedly better than the others.

VALUE OF COOLING CHILLERS

34 The chief information sought in this series of tests was whether, when a casting contracts away from a chiller, the depth of chill is increased by cooling the chiller, and at what point the cooling

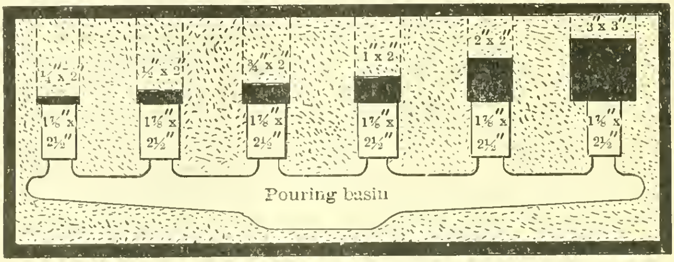


Fig. 11 Testing Efficiency of Different Thicknesses of Chillers

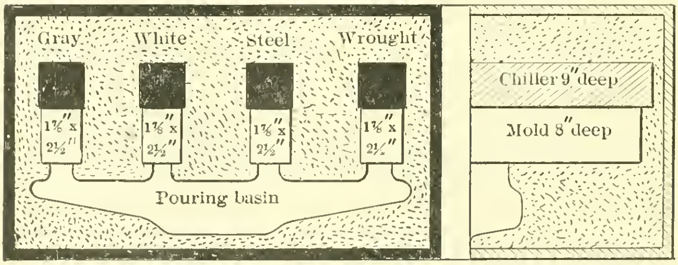


Fig. 12 Testing Efficiency of Different Metals for Chillers

ceases to have this effect. The chillers for these tests were arranged so as to have the orifices 1 to 8, Fig. 7, turned away from the face of the mold as in Fig. 8. This gave a solid surface to the body of the chiller fronting the mold, and prevented the air used to cool the chiller from impinging on the hot face of the bar. For the first tests, intervention plates *S* were used for fronting each chiller, after the ideas displayed in Fig. 7. As soon as solidification of the metal at the face of these plates would permit, they were pulled out simultaneously to create a space between the bars and their chillers, as seen by the opening at *K*, Fig. 4. The plates *S* removed, air of about 50 lb. pressure was admitted to one of the pipes, as at *W*,

Fig. 7, which passed down the bore of its chiller to find exit at X, and at the orifices 1 to 8 to the exterior of the chiller; from whence it passed upward and escaped to the external atmosphere from around the opening Y in the plan view of Fig. 8.

35 In the use of chillers for car wheels, rolls, etc., the contraction of the casting and expansion of the chiller leave a space between the two, and these tests were therefore well adapted to demonstrate whether internally or externally cooled chillers used for this class of castings would produce a deeper chill than those not cooled. Half a dozen tests were made without finding any practical difference in the depth or character of the chill produced by the air-cooled chiller bars and that of their companions which were not cooled.

36 Following these tests, fully six more were made with the plates S omitted on both sides, so as to have the bars cast directly against the face of their chillers, as displayed in Fig. 8. Here both bars remained in close contact with their chillers until cooled to a dark color. In casting these bars air of about 50 lb. pressure was admitted to one side only, passing down the pipe W and escaping at the lower exits seen at X, and thence passing upward to the external atmosphere through the space I. It was a surprise to find that this method proved practically no more effective than that just described. These tests appear to confirm those illustrated in Fig. 11 by demonstrating that there is a limit to which the thickness of a chiller affects its efficiency, and that its efficiency can not be assisted by artificial means. They forcibly illustrate the fact that if little or nothing is to be gained by holding a casting in close contact with a cooled chiller until it becomes of a dark color, it would be unreasonable to expect any benefit from a heat-absorbing medium passing rapidly through the internal body of a chiller or over its outer external surface when a space existed between the two.

CHILLING PRODUCED BY SAND-FACED MOLDS

37 It was desired to ascertain whether a chill could be created by air under pressure when prevented by a sand coating from getting directly at the hot surface of a casting. To this end the writer devised the method illustrated in Figs. 7, 13 and 14, the two last of which were experimented with at both foundries.

38 In using the mold shown in Fig. 7 an intervention core was employed, as seen on the left side. This core was about $\frac{1}{4}$ in. thick and well wired so that the head pressure of the molten metal could

not break it, when the plates R and S were pulled out together after pouring the molds. The first test of this series demonstrated the porosity of a sand mold's surface. Although this was a very hard core, the 50-lb. air pressure used carried the air through it and would have blown all the metal out of its mold had not the valve been closed. The companion bar withstood the air pressure for the reason that the plate S had formed a chilled crust on the face of the metal in the mold before its removal. Further tests with these cores under different air pressures showed that the cores prevented

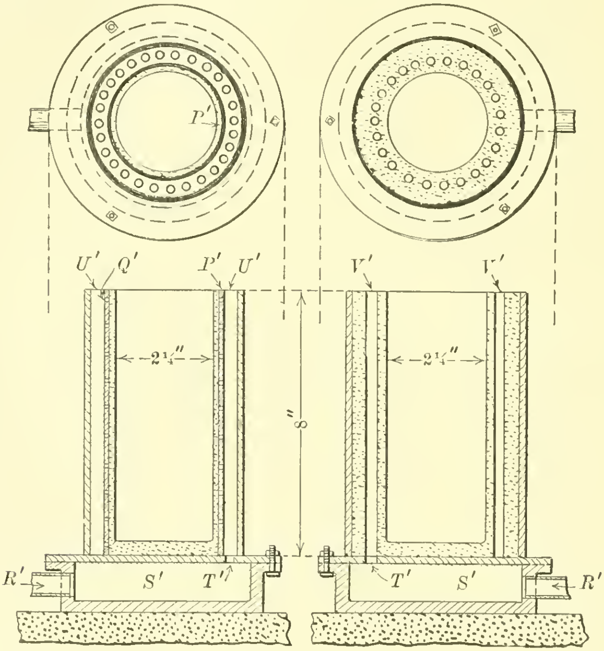


Fig. 13 Pipe Sand-Coated Air-Chilling Mold

Fig. 14 All Sand Air Cooled Mold

any chilling action, while on the other hand the air was very effective on the opposite side.

39 The difficulty with this core method lies in the fact that air under sufficient pressure to penetrate the core and carry off heat in time to create a chill will pass clear through the metal when the latter is still in a liquid or semi-molten state. This led to the designing of the method seen in Figs. 13 and 14. By a study of the sand-coated pipe P', it can be seen that any pressure up to 200 lb. and

over can be employed without causing the air to impinge against the molten metal, while at the same time it can be more effective than the core itself in conveying heat to its outer surface and then to the atmosphere. The sand coating used on this pipe was but $\frac{1}{8}$ in. thick and thoroughly dried. To carry off the gases from the sand the iron pipe was closely perforated with $\frac{3}{32}$-in. holes as at Q'.

40 Air under 60 lb. pressure entered at R' to the chamber S' and passed up through the holes T' surrounding the pipe P'. The air in the chamber U' was free to absorb heat from the pipe P' and to carry it rapidly to the atmosphere. The molds were poured without any cope or covering, care being taken to fill them only within $\frac{1}{2}$ in. or so from their tops. In about 10 seconds after pouring the mold, the air was admitted and kept in action until all the metal was thought to have solidified. A fair illustration of results is seen at M', Fig. 10. An all sand molded, non-treated companion bar was always cast from the same ladle that poured the treated bar. A sample of this is seen at N' on the right of M'.

41 There is little doubt but that the pipe P' acted as a chilling agent without the use of air, as there was only $\frac{1}{8}$ in. thickness of sand between it and the face of the casting. In fact, a test made without the air showed that the pipe aided the chilling, since it gave a density to the crust of the casting. Again it is to be kept in mind that as the diameter of the casting was only $2\frac{1}{4}$ in., its contraction would not be sufficient to create a visible space between its outer body and the face of the mold, as is generally created in casting chilled rolls, car wheels, etc. Because a chill would be created by this method, as seen at M', is no positive evidence that air passing through the inside of a hollow roll or car wheel chiller, etc., would create a deeper chill.

42 In the all sand mold, Fig. 14, which was also dried, the air passed up through holes T'', which were $\frac{1}{4}$ in. in diameter and about the same distance apart, all around the circumference, as seen by the plan view. The air escaped freely around the top at V'. The holes T'' had but about $\frac{3}{16}$ in. thickness of sand between their inner exterior and the face of the mold. Castings produced by this method showed a dense exterior or crust of from $\frac{1}{8}$ in. to $\frac{3}{8}$ in. thick, and in some instances were slightly mottled. Only in one case was there any display of chill, and this was of an irregular character $\frac{1}{8}$ in. to $\frac{1}{4}$ in. thick, created inside of a gray crust about $\frac{1}{8}$ in. thick. In reality this was an example of inside chill, one of the factors sought

in these experiments being to learn if by such methods it could be produced at will and if it was controllable.

43 It was intended also to form holes as at V' with very thin pipes drilled closely full of $\frac{3}{16}$-in. holes, and if a steady pressure of 100 to 150 lb. of air could have been secured, further efforts to learn the practicability of obtaining an inside chill with such, or similar, methods would have been tried.

44 Study of the principle embodied in Figs. 7, 13 and 14 will suggest ideas and ways and means by which grades of soft iron, aside from chilling iron, can be made more dense or crust-hardened; also by which castings or sections of castings may be cooled to prevent contraction cracks and shrink holes.

EFFECT OF A JOINT, OR SPACE, ON TRANSMISSION OF HEAT

45 It is evident that in constructing chillers to be cooled by air, etc., sufficient consideration has not been given to the question of

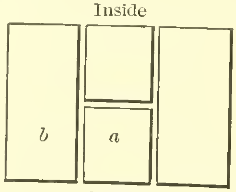


FIG. 15 ILLUSTRATING RETARDATION OF FLOW OF HEAT CAUSED BY JOINTS

transmission of heat. An excellent article by Carl Hering on The Flow of Heat through Furnace Walls [1] might be read with advantage in connection with this paper. Its author offers among other features the illustration seen in Fig. 15 with the following comments: "Moreover, the writer noticed recently in an electric furnace that the temperature of the brick at *a* in the sketch was considerably cooler than at *b*, the difference was so great that it was easily noticeable to the touch. This was no doubt due to the joint which separated the one from the inside of the furnace."

46 The principle illustrated in Fig. 15 is similar to that involved where such spaces exist as at *K*, Fig. 4, which greatly retard the absorption by the chiller of heat from the castings. It all emphasizes the utility of filling such a space as *K* with a heat-absorbing medium that can be moved swiftly from an inlet to an outlet to carry off heat for cooling, hardening or chilling purposes.

[1] Metallurgical and Chemical Engineering, September 1911.

47 It is believed that a study of the conditions will show that a rapid passage of air or other heat-absorbing media through a space as at K, Fig. 4, is very efficient for the purpose of extracting and conveying heat quickly both from the interior and exterior body of a hot casting.

TESTS ON HEAT CONDUCTIVITY OF SAND, IRON AND AIR

48 These tests were made for the purpose of ascertaining the heat conductivity of molds, composed of a sand body, and again of iron, as in chillers, instead of having a heat-absorbing medium impinge directly against the hot surface of a casting with exits for the rapid escape of the medium to the atmosphere.

49 The tests for sand conductivity were made by constructing a dry sand core $1\frac{1}{2}$ in. sq. by $7\frac{1}{2}$ in. long, with a $\frac{5}{8}$-in. port hole lengthwise through the center. This core had part of the outer face of one end cut away to provide an exit for the air forced through the interior of the core. When placed in position the core appeared practically like the chiller seen on the right of Fig. 8.

50 The tests for iron conductivity were made by having a chiller with solid face and other conditions of its position as seen on the right of Fig. 8.

51 In conducting these tests for the sand and iron, as well as with air impinging against the surface of the hot castings, only one end of the flask for twin molds was used. The mold L was formed with the same pattern, Fig. 5, as used for making all other bars. The molds were poured by a direct flow of the metal from the lip of the ladle. The top of the bars having been covered with sand and a plate to confine their heat so that the thermometer used would read correctly, the air-flow was started down the interior of the core or chiller and found an escape at the opening X and up the sides I to the top around Y, thence to the atmosphere, as in Fig. 8.

52 To obtain the temperature of the escaping air, the bulb of a thermometer capable of registering 500 deg. was held directly above and resting on the surrounding sides of the open space at Y. An assistant recorded the time and the varying temperatures of the escaping air at the first 15 and 30 seconds and afterwards each minute, as seen by lines 5 and 6 of Table 2. At the end of 10 minutes the bulb of the thermometer was held at one end of the inlet pipe after it was disconnected in order to obtain the record of line 4. At the end of 2 minutes, and after the plate and sand had been removed from the top of the bar, the bulb of the thermometer was placed so

that its frame end rested on the middle of the top end of the bar for 3 minutes, that the natural radiation of heat from the bar, seen in the last line of Table 2, might be recorded.

53 The variations in pressures and temperatures seen in lines 3 and 4 are due to changes in the speed of the compressors and to the amount of air being taken from the tank for other purposes. The seeming inconsistency of the temperature dropping at the start to only 80 deg. and 94 deg., while that which came from the tank of the compressors is 134 deg. and 124 deg., as in line 4, is due to the temperature of the core and chiller at the start being that of the atmosphere, as seen in line 2. For these reasons, the in-going air is for a few moments reduced in temperature.

TABLE 2 TEMPERATURE TESTS MADE OF THREE CASTS, OCTOBER 23, 1911

1	Body cooled with air	Sand Core	Chiller	Face of Bar
2	Temperature of atmosphere, deg. fahr	52	52	52
3	Pressure of air used, lb	55	50	50
4	Temperature of tank air, deg. fahr	134	124	130
5	Temperature escaping air at 15 sec	80	94	...
6	Temperature escaping air at 30 sec. deg. fahr	100	112	200
7	Temperature escaping air at 60 sec. deg. fahr	116	142	290
8	Temperature escaping air at 2 min. deg. fahr	120	162	310
9	Temperature escaping air at 3 min. deg. fahr	126	182	290
10	Temperature escaping air at 4 min. deg. fahr	130	182	270
11	Temperature escaping air at 5 min. deg. fahr	134	178	264
12	Temperature escaping air at 6 min. deg. fahr	136	176	252
13	Temperature escaping air at 7 min. deg. fahr	138	172	236
14	Temperature escaping air at 8 min. deg. fahr	140	170	222
15	Temperature escaping air at 9 min. deg. fahr	140	166	200
16	Temperature escaping air at 10 min. deg. fahr	138	162	192
17	Heat radiated from the bars 15 min. after they were poured, deg. fahr	208	172	70

54 A study of Table 2 shows the sand to be the least effective as a conductor of heat while the iron is not very much better when compared to the conductive power of air applied directly to the surface of the hot bar, as recorded in the last column, line 17, where it is seen that from the moment the air impinged upon the surface of the hot bars its temperature rose and in less than 30 seconds after the mold was poured reached 200 deg.

FURTHER EXPERIMENTS UPON DIRECT APPLICATION OF HEAT-ABSORBING MEDIA

55 The following experiments were largely responsible for patents granted May 1912 and pending on direct-cooling and treatment processes by pressure or suction for chilling, hardening reliev-

ing internal strains in castings, etc. These are to be utilized wherever a space can be formed adjacent to a casting, either artificially or by the natural expansion of the chiller and contraction of the casting, also when the hot surface of a casting is freely exposed to the atmosphere or not surrounded by its chiller.

56 Two twin molds were used for the experiments, each having intervention plates placed as at *S*, Fig. 7. After the two molds were poured from the same pouring basin, and a crust was formed on the face of the bars, the two plates were quickly and simultaneously removed from the mold, forming spaces as at *K*, Fig. 4. For the first experiments air of 20 lb. to 30 lb. pressure was admitted to one of the pipes, *W* Fig. 7, and conveyed directly to the space created by the removal of the plates *S* through orifices 1 to 8 in the bore of the chiller. The fast darkening of the top edge of the face of the treated bar, compared with that of the companion bar which was cooling naturally, gave good reason to expect considerable difference in the depth of chill and in the density or hardness of the chilled face of the two bars.

57 The intervention plates *S* were 2 in. wide by $\frac{1}{8}$ in. thick. A slight coating of oil was given the faces of these plates next the bars to prevent their uniting with the metal, and to permit their being drawn out of the mold quickly at the right moment.

EXPERIMENTS WITH COOLED AIR

58 Experiments were further made with air cooled by passing through a pipe coil surrounded by a mixture of two parts of cracked ice and one part of salt. The temperature was reduced thereby from 85 deg. to 45 deg. but no greater chilling effect was discovered in the six tests conducted on this plan than in the first series with the air as it came from the tanks. This is as would be expected, since the reduction of the temperature of the air by 40 deg. is so small in amount compared with the temperature of 2000 deg. which it may be assumed the surface of the molten bar would have. An increase in the pressure or volume of the air would easily discount all that could be accomplished by lowering the temperature of the air to 40 deg. as noted.

SUPERIORITY OF AIR OVER METAL CHILLERS

59 Tests were also conducted with air at higher pressures. At 50 lb. pressure a chill was created for a depth of $1\frac{1}{8}$ in. in the air-cooled bar, whereas the naturally cooled bar had a depth of chill of only $\frac{1}{8}$ in., as seen respectively at K' and L' in the bars G' and

H', Fig. 9. The gray body of both of these bars displayed a fine texture bordering on a mottled state. This test removed every possible doubt of the efficiency of air-cooling for chilling. Half a dozen or more of these tests were made before taking up others, and they all verified the results of the first tests.

60 Later on tests of the same character were conducted by having titanium and vanadium in the metal. Two sets of these samples are shown at W' and X' and again at Y' and Z', Fig. 10. Here as in G' and H', Fig. 9, the air was by far the most effective in chilling. The air-treated bars showed about $\frac{7}{8}$ in. depth of chill whereas their companions had but about $\frac{1}{8}$ in. chill.

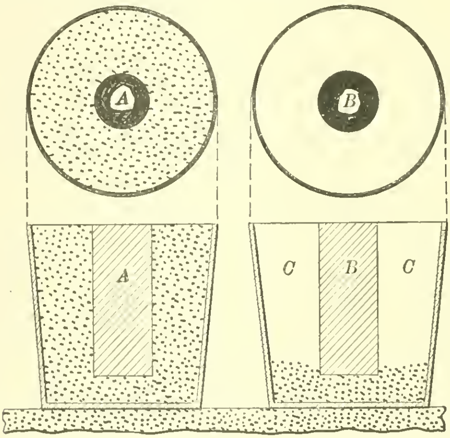


Fig. 16 Specimen Bar Cast in Open Sand and Afterwards Freed of Sand and Surrounded by Water

61 In line with these tests a series was made to determine whether air chilling was more effective than chilling by means of a solid chiller held in close contact with its bars. Samples of bars contrasting these two methods are seen at I' and J', Fig. 9, the air-cooled bar at J' having $\frac{3}{4}$ in. chill, while the other at I', produced by the close contact chiller bar, has $\frac{9}{16}$ in. chill.

62 Chilling of iron must be done before all the eutectic of the metal assumes a solid form or any graphite is formed, and with like irons the quicker and more penetrating the cooling action, the deeper and harder the chill. The direct application of a heat-absorbing medium to the surface of a hot casting, as soon as contact with its chiller is broken, or a crust is formed, provides means at a critical moment which can not but be of material benefit in

increasing the utility of cooling, densifying, or chilling and hardening of chillable and other grades of cast iron. It also provides means for securing a softer, or lower chilling and using a stronger iron in car wheels, etc., obtaining at the same time the desired depth of chill.

PRACTICABILITY OF CONTINUING CHILLING AFTER THE METAL SOLIDIFIES

63 It has always been thought that in chilling iron, the action ceased the moment the molten metal solidified. The writer's late experiments show that such is not the case; but that with chillable iron there exists a period of 20 to 30 seconds or more after the formation of a crust before any graphite is separated out. This was demonstrated as follows: At *A*, Fig. 16, is shown a casting poured in open sand, while at *B* it has been freed of its sand, this being done about $2\frac{1}{2}$ minutes after the casting was poured. Space *C* was then immediately filled with cold water, kept running until the casting was cold.

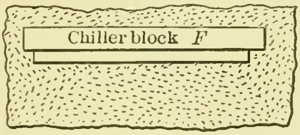


Fig. 17 Mold for Casting a Chilled Plate

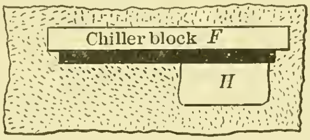


Fig. 18 Mold with Space *H* for Molten Metal

64 Upon breaking the specimen it was found, if of a high chilling iron, to be a homogeneous body of all chilled or white iron with a discolored or reddish center. But if, instead of surrounding the specimen with water at the expiration of $2\frac{1}{2}$ minutes, there were allowed to lapse 3 to $3\frac{1}{2}$ minutes before doing so, the crust exhibited graphitic formation, while the interior body was found to exist in a mottled or all-white state, showing the inside chill to have been created.

TWO NEW PRINCIPLES IN CHILLING

65 These tests indicate the existence of two laws positive in their action, as follows: First, cooling or chilling is effective in creating or continuing a chill in a casting for a period of 20 to 30 seconds after its molten metal has solidified. This permits a continuation of chilling with castings like rolls and car wheels which break contact with their chillers immediately after the formation of their chilled crust. Second, graphitization having once taken place in the crust or body

of a hot casting, no sudden cooling can restore the carbon to its original combined form, and only by remelting can it be so transformed as to have a chilled or white iron structure.

DIFFICULTIES ENCOUNTERED IN CREATING AN INTERNAL CHILL

66 With chillable irons any founder can produce a casting having an outside chill with a gray interior, but to produce one having a gray exterior and inside chill, or white body, is another proposition.

67 Mention has already been made of the sensitive nature of such a production. The variable conditions that must be considered and controlled to an exactness in order to create a perfect inside chill are as follows: (*a*) Temperature of the pouring metal;

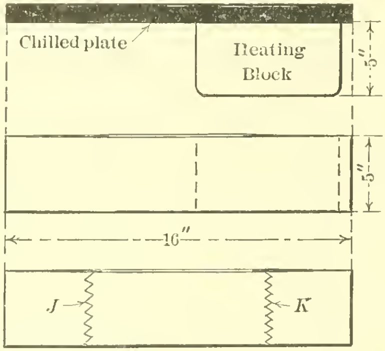


FIG. 19 CHILLED PLATE WITH HEATING BLOCK ATTACHED AND SEPARATED CASTING

(*b*) temperature of the sand; (*c*) atmospheric conditions and temperature; (*d*) nature of the iron; (*e*) size of the specimen; (*f*) temperature of the water; (*g*) whether the specimen remains stationary in its mold to be cooled or is removed or moved about in a body of water.

68 When it is stated that, for an example, with the size of specimen seen in Fig. 1, there are only some 5 to 10 seconds during 1 minute when the perfect inside chill can be created, all students of this problem will realize that at present it is a hit-and-miss process. The writer has deemed it necessary to give all the above facts, so that anyone undertaking to produce an inside or internal chill will not be led to affirm it an inpractical achievement. It will be well to state that the writer is of the opinion, that when one can obtain a medium chilling iron in place of the extremes, such will be best for creating an internal chill.

INTERNAL CHILLING TESTS WITH HIGH SILICON AND SOFT CASTING MIXTURES

69 Tests made by the writer, assisted by Mr. W. J. Strangward, superintendent, at the Forest City Foundry & Manufacturing Company, Cleveland, Ohio, showed that the high silicon in their light work mixtures caused graphitization to take place almost immediately, if not at the moment, of solidification, as the specimens exhibited no white or even mottled internal structure in any of the tests.

70 Other tests made at the Madison Foundry Company of Cleveland, upon supposed non-chilling mixtures with silicon around 2.0 and sulphur under 0.08 showed that these percentages of silicon and sulphur marked the division between chilling and non-chilling irons of the usual good working grade of foundry mixtures. The tests showed that if internal chilling could be produced with mixtures having from 2.0 to around 3.0 per cent silicon, there was a possibility that something was wrong with the physical or the chemical properties of the mixtures.

71 A feature of these tests with soft irons was that they showed a swelling in place of a shrinkage in their taps; also a greater fluidity of metal, or length of time before solidification took place. Although these bars were but about $1\frac{1}{2}$ in. in diameter they remained in a liquid state about as long as specimens $2\frac{1}{4}$ in. in diameter cast of the chillable car wheel metal.

STANDARDS FOR INTERNAL CHILLING TESTS OF HARD AND SOFT GRADES OF IRON

72 Founders and engineers interested in castings for machining, etc., might well utilize internal chilling tests as a means of determining whether there is anything in the chemical or physical properties of mixtures likely to cause chilled edges, hard spots, etc., instead of waiting for this to be found out in the machine shop.

73 The writer would suggest as a standard for such tests, bars $1\frac{1}{2}$ in. in diameter and 6 to 8 in. long for mixtures ranging from 1.25 to 3.5 per cent silicon and bars 2.4 in. in diameter of similar length for mixtures having from 0.5 to 1.25 per cent silicon.

74 In making internal chilling tests care must be exercised not to immerse a specimen in water until a self-supporting crust has been formed, or an explosion of liquid metal may occur. The use of a fair amount of intelligence and caution will guard against such dangers.

INTERNAL GRAPHITIZATION OF A CHILLED CRUST

75 Being desirous of knowing whether, after the greatest depth of a chill is created, it is possible for the intense heat of an internal body of semi-molten or solid metal to decrease the depth of a chill by graphitization, the writer conducted the following experiments: An open sand mold having a chiller block *F* was used, as seen in Fig. 17. The open sand mold was formed by plate patterns $\frac{5}{8}$ in. and $\frac{7}{8}$ in. respectively, both being about 5 in. deep and 16 in. long. After the plates were poured and solidified, a space was dug out for about half their length, as seen at *H*, Fig. 18. This space was filled with molten metal, left in close contact with the chilled plates until cooled to a dark color. The molten metal was of regular car wheel mixture, and the tests were conducted at the National Car Wheel Company's plant, Cleveland, Ohio.

76 Tests were made with the plates at different temperatures from that at which the molten metal would fuse the face of the plate, down to temperatures at which the plates were of a dark color. Upon removing these plates and body blocks of metal from the molds, the chilled plates would be separated from the blocks of metal and broken at about the points *J* and *K*, Fig. 19, to display any contrast that might exist due to the treatment. Only in one case was the plate inseparable, and in this instance the plate and block were broken by a heavy drop block.

77 In all of these experiments a drawing of the chill in depth was displayed by reason of the hot molten metal causing a graphitization of the chilled face abutting it. The experiments made with the hottest plates showed the greatest effect, and such as to produce about a 25 per cent graphitization of the chilled plates face that abutted the hot metal. This effect was exhibited by a fairly uniform decrease of the graphitization down to the coldest plates, which showed but a slight effect of the treatment.

TESTS OF CHILLABLE IRONS

By Thos. D. West

ABSTRACT OF PAPER

The tests given in this paper relate to the relative strength of gray iron and of partly or wholly chilled iron, showing the best combination in chilled castings. Many tests are presented of chillable iron alloyed with vanadium and titanium.

Previous to these tests experiments were made for the purpose of establishing a size of round bars suitable for making tests of chillable irons where it is necessary to have the bars either of a uniform gray structure throughout or capable of being chilled throughout, the metal in each case being poured from the same ladle.

The effect is shown on the results of tests of different methods of locating the bar in testing with regard to the quality or grain of the metal. Attention is called to the advisability of drop tests for cast iron and to the complexity and sensitiveness of chillable iron mixtures, requiring delicacy in mixing, melting, casting and testing.

TESTS OF CHILLABLE IRONS

By Thos. D. West, Cleveland, Ohio

Member of the Society

The paper presents an original series of tests of chillable irons, made during September 1911 to the close of February 1912.

2 Before proceeding with the tests it was desired to find what size of bar should be used with different grades of iron to produce a bar of all gray iron and at the same time a companion bar that could be wholly chilled, or of a white iron, both poured from the same basin or ladle. Sets Nos. 1 and 2 show that bars $1\frac{5}{8}$ in. in diameter are suitable for various grades of chillable metal having its silicon ranging from 0.90 to 1.20. The balance of the sets show $2\frac{1}{4}$ in. diameter bars to be suitable for many grades having a range of 0.50 to 0.90 per cent silicon. It is to be understood that in either of the above the constituents, other than silicon, are generally the same as used in the making of such castings as chilled car wheels and rolls. In some cases the larger bars may be used for higher silicon metal, this depending chiefly upon the metal being high in sulphur and no ferro-manganese being used.

3 While the round bar is advocated for a standard, it is to be understood that there are cases of experimental work such as presented in this paper, where square bars may be advisable, but for ordinary practice to obtain comparisons in mixtures, grades of metal, etc., the round bars are to be preferred.

4 For molding the square bars three flasks were constructed, each being adapted to cast three or four bars. These bars were 2 in. sq. by 24 in. long. For casting the round bars, two chiller molds having a bore of $1\frac{5}{8}$ in., later on bored out to $2\frac{5}{16}$ in., were used in connection with two pipe sand molds. The designs for both are seen in Figs. 1 to 6 in the paper, A Suggested System of Test Bars for Chillable Irons, to be presented by the writer before the Sixth

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Congress of the International Association for Testing Materials in September 1912. The three sets of flasks were often necessary, as in the case of making bars to test the relative effects of vanadium and titanium as alloys.

METHODS FOR OBTAINING AND ALLOYING METALS TO TEST THEIR EFFICIENCY

5 In casting sets for these tests, the bars were poured with the regular metal from a reservoir ladle under the cupola spout, with a capacity of about 7 tons, and carried to the molds in a "bull ladle" which held about 250 lb. Twelve ounces of ferro-manganese was thrown into the ladle, in order to secure the same composition as used for car wheels where 2 to $2\frac{1}{2}$ lb. of ferro-manganese is added to every 700 or 800 lb. of metal.

6 After the bars were poured of this regular wheel metal the bull

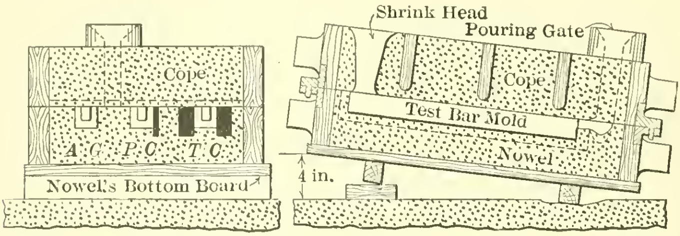

Fig. 1 Sectional Views of Mold for making the Square Test Bars

ladle was again filled as often as needed and vanadium or titanium, or both together, added according to the tests to be made, along with the 12 oz. of manganese. The ladle was allowed to stand for three or four minutes to permit the alloys to melt thoroughly and mix with the metal. A $\frac{1}{2}$-in. rod was used to agitate the metal to help bring any oxides created by the alloys to its surface. The two, three or more bull ladles of metal required for a set were taken from the reservoir ladle before any additional tap of metal was run into it from the cupola.

METHOD OF CASTING AND CHILLING THE ALLOYED METAL

7 In pouring either of the above alloyed metals with the regular metal to obtain a set of square bars, a set of round bars would be poured with the same ladle.

8 In casting the square test bars, some had a 2 in. by $2\frac{1}{2}$ in. chiller on two sides, as illustrated at *TC* in the end view of Fig. 1, so as thoroughly to chill the bar to make it all white iron. Others

had a wrought plate $\frac{1}{4}$ or $\frac{1}{2}$ in. thick as desired, on one side of the bar only, as at *PC*, in order only partly to chill one side of the bar. Bars to be free of chill, were surrounded with sand as seen at *AG*. In some cases two totally chilled bars and one all gray bar might be cast in the one flask. Again, two partially chilled, one totally chilled, and one all gray bar might be cast in one flask. This order could be changed in providing for three to four bars being made in a flask.

9 The character of the chill, or grain of iron, is given in the tables under the heading Fracture. Should an all sand molded bar show

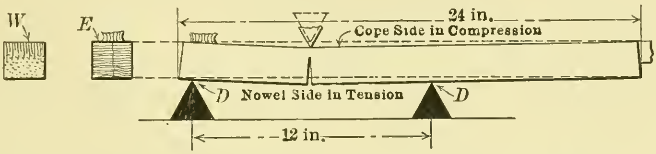

Fig. 2 End and Side Views of a Test Bar made in Mold, Fig. 1
W shows Gray Side in Tension and Strong Position; *E* shows Horizontal Plane of Chill Crystal in Tension and Weak Position

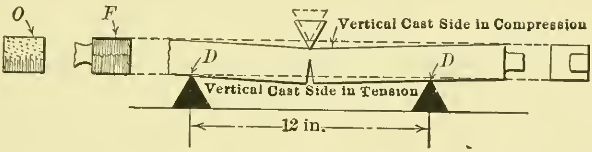

Fig. 3 Second Test on a 2-In. Sq. Bar
O shows Chilled Side in Tension and Weak Position; *F* shows Vertical Plane of Chilled Crystal in Tension and Strong Position

a slightly mottled grain in its fracture instead of being all gray, the words slightly mottled are inserted. Should the fracture be strongly mottled the notation is the word " deeply " in the place of " strongly." In cases where the depth of a partly chilled bar was measured the thickness of the chill is given in connection with the statement that one side was chilled.

10 To indicate that one of the vertically cast sides, also the cope surface, or the nowel face of a bar is in tension when testing a bar, the words nowel, cope and side are placed on the line with the respective bar in the column headed Tension. This will be better understood by referring to Figs. 2 and 3 where the side and end view of the bars are shown in two ways of being tested. In the case of round, as well as square bars that are cast on end, as were Nos. 84

and 88, it makes no difference which way they are placed on the distance supports *D*, Figs. 2 and 3, when being tested.

11 The width and depth as well as the diameter of all the tested bars are given in Tables 3–10 to permit a checking of the modulus of rupture column; also present data for other formulae for computing variations in the size of the bars shown. It is to be understood that the records of all tests given are of solid bars and complete fractures; as should there have been a slight flow in any of those tested it would have been in the compression face of the bar where it could have no effect in reducing its strength.

METHODS USED FOR TRANSVERSE TESTING AND PRACTICABILITY OF DROP TESTS

12 All transverse tests on both round and square bars, Tables 5 to 9, except tests 59 and 77, were made with a 12-in. span, and all drop tests of Table 10 with an 8-in. span; all others were tested

TABLE 1 RANGE OF CHEMICAL ANALYSIS FOR CHILLED CAR WHEELS

Silicon	Sulphur	Manganese	Phosphorus	Combined Carbon	Graphitic Carbon
0.55 to 0.65	0.100 to 0.150	0.55 to 0.70	0.270 to 0.320	0.60 to 0.70	2.70 to 2.90

for the transverse and drop test on a 12-in. span, as seen in Figs. 2 and 3. Tests 59 and 77 were made with a 10-in. span. All drop tests of Tables 5 to 9 were made with a 12-in. span and all drop tests for Table 10 were made with an 8-in. span.

13 The drop tests were made with a 25-lb. weight having the first drop at a height of 6 in. and raised 6 in. higher for every blow until breaking the bar. If for example, 6 is the number in the drop column of the tables, it means that the weight dropped once at each of the respective heights, 6 in., 12 in., 18 in., 24 in., 30 in., and 36 in., before breaking the bar. The bars for the drop tests Tables 5 to 9 were obtained by taking the long end of the 24-in. long square bars after they had stood one transverse test. This is why two kinds of tests with the same bar are given under the same test number.

14 A comparison of the drop tests with the transverse tests shows that where a bar is strong transversely it generally shows a relatively high strength under the drop test. This was also true in the case of nearly all of the round bars having a 6-in. span, but these tests are not given herein.

15 For castings that are subject to shock or sudden impact, such as car wheels, rolls, shears, dies, etc., the drop test should grow in favor. The apparatus costs little and the time required is less than that needed in any other method of testing.

TREATMENT AND ANALYSIS OF REGULAR CAR WHEEL AND ALLOYED METALS

16 No special complete analysis is given of the respective sets

TABLE 2 ANALYSIS OF SETS ALLOYED WITH VANADIUM AND TITANIUM

Set No.	Oz. of Vanadium in 225 Lb. of Metal	Oz. of Titanium in 225 Lb. of Metal	Per Cent of Vanadium in Test Bars	Per Cent of Titanium in Test Bars	Per Cent of Manganese in Test Bars
9	10	..	0.06	....	0.63
11	..	10	....	0.02	0.72
13	22	..	0.12	....	0.64
15	..	22	....	0.07	0.60
18	5	10	0.04	0.03	0.69
19	8	15	0.05	0.05	0.68

TABLE 3 TRANSVERSE TESTS 1¾ IN. SQ. AND 1⅝ IN. ROUND BARS AND CRYSTALLIZATION

Test No.	Fracture	Width	Depth	Tension	Maximum Load	Deflection	Modulus	Set No.
1	All white	1.73	1.72	Nowel	5140	0.016	18070	1
2	All white	1.68	1.69	Side	13160	0.028	49380	1
3	Slightly mottled	1.75	1.76	Side	15300	0.060	50820	1
4	All white	1.59	diameter	...	4780	0.023	36280	1
5	Slightly mottled	1.60	diameter	....	7340	0.065	54670	1
6	All white	1.69	1.69	Nowel	7580	0.028	28260	2
7	All white	1.71	1.71	Side	15280	0.042	55010	2
8	Strongly mottled	1.72	1.79	Side	11940	0.038	39000	2
9	All white	1.60	diameter	....	5820	0.032	43350	2
10	Almost white	1.56	diameter	....	5540	0.040	44520	2
11	All white	1.59	diameter	....	3080	0.021	23370	3
12	Strongly mottled	1.58	diameter	....	7760	0.073	60030	3

other than that in Table 1. This is owing to the fact that car wheel mixtures or analyses, from one foundry at least, vary but little. Table 2 gives the vanadium and titanium constituents of the test bars. Analyses of metal taken directly from the reservoir ladle before the ferro-manganese was added showed this metal to contain around 0.40 manganese. The drillings for regular car wheel metal

analyses are taken from blocks about 2 in. by $2\frac{1}{2}$ in. by 8 in. cast in all sand so as to leave a gray body in the metal, which will agree closely with the gray between the plate and body back of the chill of a car wheel.

SENSITIVE CONDITIONS REQUIRING CONSIDERATION AND CONTROL IN TESTING CHILLABLE IRONS

17 Table 3 shows that bars $1\frac{3}{4}$ in. square and $1\frac{5}{8}$ in. round are too small for regular car wheel metal. This is seen by the all-sand bars 3, 5, 8, 10 and 12, showing a fracture a little too strongly mottled instead of a fair gray structure. These sizes of bars are recommended only for chillable irons ranging from 0.90 to 1.20 per cent in silicon for use in general practice.

18 The foregoing is a general statement requiring modifications in some instances. A comparison of the strength of bars 4, 5, 11 and 12 with 9 and 10 shows the cases in which strongly mottled iron of the same metal, also iron tending to all white, as No. 10, will give exceptional strength. Many other round bars $1\frac{5}{8}$ in. in diameter were made, but broken with the sledge to check these fractures. The two odd bars 11 and 12 are shown chiefly to demonstrate the distinction they display.

19 When a bar is of such a size that it is sensitive to assume a mottled form, it is very likely to go further and become almost white, and with the same iron, temperature of metal and character of mold, there is as much chance to obtain a strength of 7760 lb. as 5540 lb., as seen for bars 10 and 12. But this sensitive condition must be avoided in order better to make comparisons between an all-chilled bar and an all sand cast one of the same size, form, and metal. To do this, it is necessary to have the sand cast bars sufficiently large to prevent their taking a mottled form, and still not so large as to prevent their being absolutely chilled, or all white iron to their very center, when cast in an all-iron mold or chiller of the same diameter. Much experimenting may often be necessary to learn to know the best size to adopt for making a comparison between the white and gray of special chillable irons. It will be seen by the tables having the $2\frac{1}{4}$-in. round bars, that even with this increase over the $1\frac{5}{8}$ in. in diameter, some of the larger bars show a slightly mottled fracture with the silicon around 0.60. This could have been largely avoided by baking or drying the sand molds, as those used in the tests shown were all of green sand. To increase the size of the round bar would assist this feature, and such could be done to the extent of having it

$2\frac{3}{4}$ in. and possibly 3 in. in diameter and still produce a perfect, all-chilled bar for a companion to an all sand cast or gray one having the silicon around 0.60.

20 It is important therefore to describe the structure of fractures when recording tests of chillable iron and in making comparisons with all-chilled and gray bars or otherwise. It all shows that in some cases, it may be necessary to experiment in order to obtain the diameter best suited to give a knowledge of the relative strength of

TABLE 4 TRANSVERSE TESTS OF VARIABLE DEPTHS OF CHILL WITH LOW CHILLING IRONS

Test No.	Fracture and Per Cent of Chill	Width	Depth	Load	Deflection	Modulus	Set No.
13	Not chilled; clear gray iron	1.01	1.51	5615	0.098	43900	4
14	Chilled one side; 10% white	1.00	1.50	4360	0.085	34900	4
15	Chilled two sides; 25% white	0.96	1.44	3270	0.056	29600	4
16	Not chilled; clear gray iron	0.98	1.46	5175	0.105	44500	5
17	Chilled one side; 15% white	1.03	1.48	4220	0.069	33700	5
18	Chilled two sides; 20% white	1.02	1.45	4390	0.079	36900	5
19	Not chilled; clear gray iron	0.97	1.47	5000	0.103	43000	6
20	Chilled one side; 1% white	1.00	1.47	5610	0.108	46750	6
21	Chilled two sides; 100% white	1.01	1.47	6400	0.080	52800	6
22	Not chilled; clear gray iron	1.00	1.46	4350	0.157	36700	7
23	Chilled one side; 5% white	0.99	1.43	4550	0.159	40500	7
24	Chilled one side; 20% white	1.06	1.50	4200	0.137	31700	7
25	Chilled two sides; 50% white	1.02	1.50	2300	0.110	18050	7

the white and gray of chillable irons. This does not prevent the adoption of a standard to be used the world over[1] for tests for chillable irons. All that is necessary is to state the structure of the fracture, diameter of the bar used, per cent of silicon, and possibly other constituents, should they vary much from those given in Table 1.

ERRATIC EFFECTS OF CHILLED CRYSTALS AND INTERLACING OF THE GRAY WITH THEM

21 Table 4 presents a few of the many tests made with chillable metal, having about the following composition: silicon 2.0, sulphur 0.06, phosphorus 0.04, manganese 0.30. The bars were made in a

[1] Suggested by the author in a paper, A Suggested System of Test Bars for Chillable Irons, prepared for the Sixth Congress of the Int. Assoc. for Testing Materials for their meeting, to be held Sept. 1912.

TABLE 5 BARS 26 TO 30 HAD 12 OZ. MANGANESE; 31 TO 34, 12 OZ. MANGANESE AND 10 OZ. VANADIUM IN 225 LB. OF METAL

Test No.	Fracture and Per Cent of Chill	Width	Depth	Tension	Load	Deflection	Modulus	Drop	Set No.
R 26	Chilled both sides. All white iron	2.04	2.00	nowel	15150	0.030	33420	4	8
R 27	Chilled ½ in. one side	2.10	2.05	nowel	14330	0.036	29230	6	8
R 28	All gray iron	2.12	2.08	nowel	23860	0.070	46820	9	8
R 29	All gray iron	2.31	diameter	....	25750	0.095	63710	..	8
R 30	Chilled. All white iron	2.21	diameter	....	14620	0.030	41330	..	8
V 31	Chilled two sides. All white iron	2.08	1.97	nowel	16100	0.030	35900	4	9
V 32	Chilled ⅝ in. one side	2.05	1.99	nowel	15370	0.035	34080	5	9
V 33	All gray iron	2.08	2.00	nowel	22020	0.070	47640	9	9
V 34	All gray iron	2.32	diameter	....	23430	0.070	57300	..	9

Set *R* poured with regular iron. Set *V* poured with vanadium in regular iron. Set *T* poured with titanium in regular iron.

TABLE 6 BARS 33 TO 39 HAD 12 OZ. MANGANESE; BARS 40 TO 44, 12 OZ. MANGANESE AND 10 OZ. TITANIUM IN 225 LB. OF METAL

Test No.	Fracture and Per Cent of Chill	Width	Depth	Tension	Load	Deflection	Modulus	Drop	Set No.
R 35	Chilled both sides. All white	2.14	1.98	nowel	22420	....	48108	..	10
R 36	Chilled $\frac{7}{16}$ in. one side	2.03	2.07	nowel	18990	0.037	39170	3	10
R 37	All gray iron	2.12	2.04	nowel	25740	0.075	54700	11	10
R 38	All gray iron	2.27	diameter	....	25520	0.077	66570	..	10
R 39	Chilled. All white iron	2.22	diameter	....	13440	0.024	37477	..	10
T 40	Chilled both sides. All white	2.02	1.97	nowel	16100	0.031	36960	4	11
T 41	Chilled ⅜ in. one side	2.07	2.00	nowel	15130	0.032	33280	5	11
T 42	All gray iron	2.06	1.99	nowel	21870	0.074	48250	9	11
T 43	All gray iron	2.32	diameter	....	23400	0.059	57180	..	11
T 44	Chilled. All white iron	2.22	diameter	....	17110	0.028	47711	..	11

TABLE 7 BARS 45 TO 49 HAD 12 OZ. MANGANESE; BARS 50 TO 54, 12 OZ. MANGANESE AND 22 OZ. VANADIUM IN 225 LB. OF METAL

Test No.	Fracture and Per Cent of Chill	Width	Depth	Tension	Load	Deflection	Modulus	Drop	Set No.
R 45	Chilled both sides. All white	1.90	2.02	nowel	16460	0.030	38220	5	12
R 46	Chilled ⅜ in. one side	2.10	2.00	nowel	14380	0.035	30810	7	12
R 47	All gray iron	2.08	2.01	nowel	23790	0.090	50960	11	12
R 48	All gray iron	2.29	diameter	....	23910	0.078	60730	..	12
49	Chilled. All white iron	2.22	diameter	....	15610	0.022	43520	..	12
V 50	Chilled both sides. All white	2.00	1.98	nowel	16030	0.035	36800	4	13
V 51	Chilled $\frac{7}{16}$ in. one side	2.10	2.02	nowel	14090	0.030	29600	3	13
V 52	Gray, slightly mottled	2.05	2.00	nowel	24800	0.065	54440	7	13
V 53	Gray, slightly mottled	2.27	diameter	....	25580	0.060	66710	..	13
V 54	Chilled. All white iron	2.20	diameter	....	17890	0.025	51250	..	13

TABLE 8 BARS 55 TO 59 HAD 12 OZ. MANGANESE; BARS 60 TO 64, 12 OZ. MANGANESE AND 22 OZ. TITANIUM IN 225 LB. OF METAL, WHILE BARS 65 TO 68 WERE FREE FROM MANGANESE AND OTHER ALLOYS

Test No.	Fracture and Per Cent of Chill	Width	Depth	Tension	Load	Deflection	Modulus	Drop	Set No.
R 55	Chilled both sides. All white	2.00	2.00	nowel	15980	0.030	35960	4	14
R 56	Chilled ⅜ in. one side. Balance mottled	2.00	2.07	nowel	18140	0.038	38100	4	14
R 57	Gray iron. Corners chilled	2.02	2.00	nowel	22720	0.070	50610	7	14
R 58	Gray iron, slightly mottled	2.25	diameter	....	26000	0.075	69640	..	14
59	Chilled. All white	2.24	diameter	....	13830	0.017	33966	..	14
T 60	Chilled both sides. All white	2.00	1.98	nowel	13200	0.025	30300	4	15
T 61	Chilled ½ in. one side. Balance mottled	2.04	2.03	nowel	16840	0.035	36060	4	15
T 62	Gray, corners slightly chilled	2.05	2.00	nowel	22080	0.075	48470	10	15
T 63	Gray iron	2.26	diameter	....	25810	0.08	68230	..	15
T 64	Chilled. All white iron	2.22	....	....	16070	0.05	44810	..	15
S 65	Chilled both sides. All white	2.04	2.04	nowel	11400	0.020	24170	3	16
S 66	Chilled ⅝ in. one side. Deeply mottled	2.06	2.04	nowel	10860	0.030	22800	3	16
S 67	Gray, corners mottled	2.04	2.00	nowel	17870	0.050	39420	5	16
S 68	Gray iron, mottled	2.25	diameter	....	24180	0.065	64204	..	16

Set *S* poured with spurious metal containing no ferro-manganese.

TABLE 9 BARS 69 TO 72 HAD 12 OZ. MANGANESE; BARS 73 TO 77, 10 OZ. TITANIUM AND 5 OZ. VANADIUM; BARS 78 TO 82, 12 OZ. MANGANESE, 15 OZ. TITANIUM AND 8 OZ. VANADIUM IN 225 LB. OF METAL

Test No.	Fracture and Per Cent of Chill	Width	Depth	Tension	Load	Deflection	Modulus	Drop	Set No.
R 69	Chilled both sides. All white	1.98	2.02	nowel	18480	0.035	41170	5	17
R 70	Chilled ¼ in. one side. Balance mottled	2.04	2.50	nowel	16760	0.055	23660	6	17
R 71	All gray iron	2.05	2.05	nowel	24390	0.085	51020	11	17
R 72	All gray iron	2.27	diameter	....	24030	0.065	62660	..	17
*TV*73	Chilled both sides. All white	2.02	2.00	nowel	12330	0.025	27470	..	18
*TV*74	Chilled ⅛ in. one side. Balance mottled	2.05	2.07	nowel	18340	0.040	37580	6	18
*TV*75	All gray iron	2.10	2.04	nowel	24980	0.065	51390	11	18
*TV*76	All gray iron	2.29	diameter	....	22070	0.060	56060	..	18
*TV*77	Chilled. All white iron	2.21	diameter	....	16370	0.029	38560	..	18
*TV*78	Chilled both sides. All white	1.96	2.03	nowel	16250	0.030	36210	4	19
*TV*79	Chilled ¼ in. one side. Balance mottled	2.00	2.04	nowel	14580	0.040	31530	5	19
*TV*80	All gray iron	2.04	2.00	nowel	22240	0.065	49060	8	19
*TV*81	All gray iron	2.29	diameter	....	23470	0.060	59620	..	19
*TV*82	Chilled. All white iron	2.20	diameter	....	18700	0.030	53570	..	19

converter steel foundry and tested by John H. Nelson; all others were tested by H. E. Smith. In testing this set, the load was applied in the deep direction of the bars which were all cast on end. Tests 13 to 25 illustrate the erratic qualities of partly chilled bodies, accounted for by the interlacing of the white with the gray and the depth of mottled iron back of the chilled body.

22 In partly chilled sections, the temperature of the chiller to chill the iron, and of the metal to pour the mold, and the degree of dampness in the sand, have an effect both on the depth of chill, and on the structure of the metal for a considerable distance beyond the place where the white ceases. These are all factors difficult to control in regular practice, but the more that is known concerning them, the better will be the design, make and use of the castings. The variable hardness of mottled and gray bodies, interlacing with the white iron of chilled bodies, are displayed by the hardness tests, Table 12.

TRANSVERSE AND DROP TESTS OF GRAY AND CHILLED BARS ALLOYED WITH VANADIUM AND TITANIUM

23 Tables 5 to 9 present an original series of tests comprising the following features:

a Comparison of strength, deflection, chill and contraction, in all-chilled, partly-chilled, and gray bars of the same metal.

b Comparison of square and round bars to emphasize the utility of the latter for a standard.

c Comparisons of transverse and drop tests to show their conformity, and practicability of the latter.

d Comparisons of hardness created by the rate in cooling, giving chilled, mottled and gray fractures in the same metal.

e Effects of ferro-manganese, vanadium, and titanium in the same metal and size of section, when of a chilled, mottled and gray structure.

24 Results of the above comparisons in connection with those to be derived from a study of the tables are given throughout the paper.

NOTABLE DIFFERENCE IN THE STRENGTH OF THE CHILLED AND GRAY SIDES OF A PARTLY CHILLED CASTING

25 It will be seen from tests in Table 10 that when the chilled face is in extension, as with Tests 92, 94 and 96, the casting is much

weaker than when the gray or mottled body is in extension, as with Tests 91, 93 and 95 of Set 22. This is a quality having heretofore received very little, if any, thought. When fully considered it will be seen to be of great importance in the making and use of different lines of castings. The reliability of this set of tests will be realized when it is understood that the respective companion tests having the chilled side in compression and tension were made

TABLE 10 TRANSVERSE AND DROP TESTS OF ONE SIDE CHILLED BARS ALTERNATED TO BE IN COMPRESSION AND TENSION

Test No.	Fracture and Per Cent of Chill	Width	Depth	Load	Deflection	Modulus	Drop	Set No.
83	Gray iron, slightly mottled	2.09	2.06	21070	0.045	42760	7	20
84	Chilled four sides. All white	2.12	2.18	23380	0.040	41770	15	20
85	Chilled ⅝ in. one side. Balance mottled. Gray side in tension	2.06	2.05	21590	0.030	43435	9	20
86	Chilled 9/16 in. one side. Balance mottled. Chilled side in tension	2.07	2.03	20430	0.035	43111	7	20
87	Gray iron, slightly mottled	2.11	2.07	19420	0.045	38664	8	21
88	Chilled four sides. All white	2.06	2.20	22450	0.020	40532	15	21
89	Chilled 11/16 in. one side. Balance mottled. Gray side in tension	2.10	2.04	19880	0.050	40947	8	21
90	Chilled 11/16 in. one side. Balance mottled. Chilled side in tension.	2.06	2.06	13660	0.030	28132	6	21
91	Chilled ¼ in. one side; ¾ in. mottled. Gray side in tension	2.11	2.15	23760	0.070	43861	14	22
92	Chilled ¼ in. one side; ¾ in. mottled. Chilled side in tension	2.13	2.06	17260	0.035	34373	..	22
93	Chilled ¼ in. one side; ¾ in. mottled. Gray side in tension.	2.12	2.10	21760	0.055	41914	7	22
94	Chilled ¼ in. one side; ¾ in. mottled. Chilled side in tension.	2.13	2.06	13190	0.025	26378	..	22
95	Chilled ½ in. one side; 1 in. mottled. Gray side in tension.	2.11	2.03	20350	0.055	42127	5	22
96	Chilled ½ in. one side; 1 in. mottled. Chilled side in tension.	2.13	2.13	15720	0.030	29281	..	22

with the same bar, by the method shown in Figs. 2 and 3. After making two transverse tests of the same bar, there was sufficient remaining for a drop test having an 8-in. span. A few of these are Tests 83 to 96. Bars 83 to 90 were cast on end, while bars 91 to 96 were cast flat, as shown in Fig. 1, and chilled on one side only to give two of this form for one set. In Fig. 6 is seen a full set of the square bars cast on end, in which M is the all chilled bar, N the chilled side, and O the gray side of the partly chilled bars, while P is the all sand cast bar. The position of the chilled face

in the testing is shown at W for both the cast on end and cast flat bars when upward, and at O when downward, seen on the left of Figs. 2 and 3.

26 Another feature is the great difference between the strength of chilled iron when the lines of crystallization stand vertical to the load, and when they are turned horizontal to it. In Table 3, Tests 1, 2, 6 and 7 show a difference of about 61 per cent for the first two bars, and about 51 per cent for the second two. The lines of crystallization are seen in Figs. 2 and 3, where *E* is the weakest and *F* the strongest position of the two-sided bar. These qualities were original-

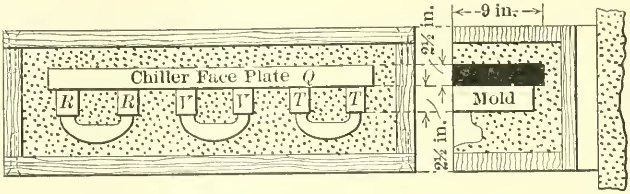

Fig. 4 Open Sand Mold for making Comparative Chilling Tests

ly discovered by Asa W. Whitney, and are presented here to give data in keeping with the original tests of this paper.

CRITICISM ON AND CHILLING EFFECTS OF VANADIUM AND TITANIUM

27 William H. Hatfield in a paper On The Influence of Vanadium upon Cast Iron [1] at the March 1911 meeting of the Iron and Steel Institute, stated, "There is considerable disagreement as to the influence of vanadium." Expressions of this character had much weight in the taking of extra precautions when testing these alloys, in the belief that the results might settle some of the disputed points.

28 Information of the chilling qualities of the alloys is given in Pars. 29 to 31 and in the various sets of Tables 5 to 9, as Tests 27 and 32. It required but a few tests to show that the difference in the pouring temperature of the metals, due to the cooling effect produced in melting the alloys, was such as to make the depth of chill shown in Tables 5 to 9 an uncertain factor for these tests. This is more fully realized when the fact is considered that "hot" metal will chill deeper than "dull" metal.

29 To obtain more favorable conditions for rapid pouring and less travel of metal than was offered by the mold, Fig. 1, cupola chill

[1] The Journal, Iron & Steel Institute, vol. 83, no. 1, p. 318.

blocks were made after the plain and end views in Fig. 4. The pair of chilled blocks *R* were poured with the regular car wheel metal, cooled down to nearly the same temperature as that for pouring the chill block molds *V* and *T* having the vanadium and titanium alloys in their respective ladles. This method emphatically demonstrated that the vanadium increased the depth of chill, or held the carbon more in its combined form, while the titanium operated in the opposite direction. Numerous tests were made following this plan, some of

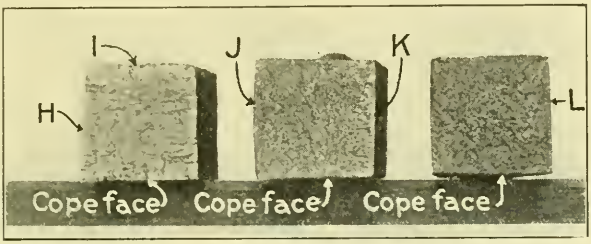

FIG. 5 SET OF ALL CHILLED, PARTLY CHILLED AND ALL SAND SQUARE BARS CAST FLAT

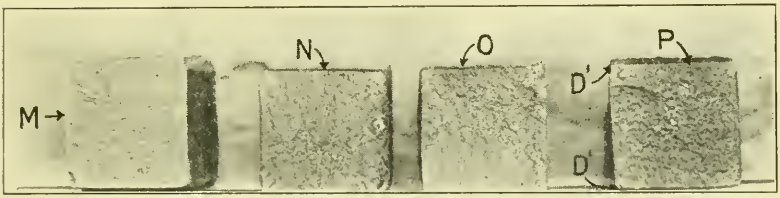

FIG. 6 SET OF ALL CHILLED, PARTLY CHILLED AND ALL SAND SQUARE BARS CAST ON END

which had a $\frac{1}{2}$-in. chiller face plate in place of the $2\frac{1}{2}$-in. plate *Q*, and all of them were effective in the same direction as to their respective results.

30 One test with the three sets of molds, Fig. 4, gave a difference in the thickness of chill as seen at *X*, *Y* and *Z*, Fig. 7. The Set *R* was poured with the regular iron; the Set *V* with the vanadium and the Set *T* with the titanium alloyed metal, there being 1 lb. of each alloy in about 175 lb. of metal.

31 Further experiments having 2 lb. of titanium in the 175 lb. of metal gave a thickness of chill seen at *V* and *W*, Fig. 7, of 1 in. and $\frac{1}{2}$ in. respectively as marked in the cuts. In the belief that by

increasing the amount of titanium the chill might be wholly prevented, 4 lb. was put into the metal for two tests. This did not act as effectively as the 2 lb. and showed that iron could not be prevented from chilling beyond a certain limit by its use.

EFFECTS OF VANADIUM, TITANIUM AND OTHER FACTORS ON CONTRACTION

32 Tests to obtain contraction were made with both round and square bars and are given in Table 11. The $2\frac{1}{4}$-in. round bars show the contraction for a length of 12 in. and the square bars for 22 in. The ratios for contraction of the bars cast on end agree closely with those of the bars cast flat. The regular irons are fairly uniform in

TABLE 11 CONTRACTION OF ROUND BARS CAST ON END AND SQUARE CAST FLAT

Set No.	Round Bars, All Chilled	Round Bars, All Gray	Square Bars, All Chilled	Square Bars, Part Chilled	Square Bars, All Gray
R 12	0.22	0.12	0.47	0.28	0.26
V 13	0.23	0.13	0.48	0.30	0.27
R 14	0.22	0.12	0.47	0.28	0.26
T 15	0.21	0.11	0.43	0.29	0.25
S 16	...	...	0.50	0.36	0.32
R 17	...	...	0.48	0.31	0.28
TV 18	0.22	0.12	0.47	0.29	0.26
TV 19	0.23	0.12	0.48	0.30	0.27

their contraction. The vanadium bars show a greater contraction than those containing titanium, the latter having the least of any of the metals. The spurious metal of Set 16 having no ferro-manganese in it, shows the greatest contraction. The most radical difference exists between the all-chilled and all gray bars.

EFFECTS OF VANADIUM AND TITANIUM ON STRENGTH

33 In making deductions of the relative strength for the alloy mixtures, etc., the round bars were selected chiefly on account of their uniform structure and greater uniformity of results. Fig. 8 is a good illustration of the uniformity of the metal as it comes in round bars rather than in square ones. The gray round bar A' shows a much better uniformity of grain structure than exists in the square bars L and P, Figs. 5 and 6. These last present irregular patches of grains embodying every structure from white at the corners D', interlaced with mottled, leading to a gray center, sensitive to change with the least variation in the dampness or character of the sand, hardness in ramming and temperature of pouring metal. This irregularity

of structure is likewise apparent in the all white square bars *H* and *M*, Figs. 5 and 6, when compared to that seen at *B'*, Fig. 8.

34 The titanium bars show an increase of strength over the regular bars of 27 per cent in the white iron with bars 39 and 44, Table 6, and 32 per cent in the white iron with bars 59 and 64, Table 8.

35 The vanadium shows an increase of strength of 9 per cent in the gray iron, with bars 48 and 53, and 17 per cent in the white with bars 49 and 54, both of Table 7.

36 The spurious bars which have no ferro-manganese or other alloys in them, show a decrease of strength of 7 per cent in the gray

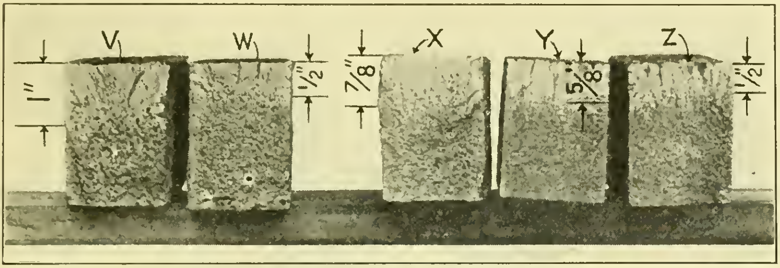

Fig. 7 Specimens affected by Cooling and Varying Percentages of Vanadium and Titanium

iron, with bars 63 and 68 of Table 8. No comparison of the white iron in the round bars can be given, since there are no chilled round bars for this last set; but the contrast is so great in the square chilled bars 55 and 65, which show the white of the spurious metal, that it is safe to consider them 30 per cent weaker than the regular iron.

37 Some tests having shown vanadium and titanium beneficial in increasing the strength, it seems reasonable to suppose that all the other sets having them alloyed in the regular metal should show a similar tendency. It may be that in car-wheel metal there is a definite absorption of the alloys necessary to increase materially the strength of the gray and white. By the use of large round test bars for making the relative comparison in these irons, further experimenting with this grade of metal along practical lines should establish beyond any doubt the question of such a limit.

COMPARISON OF PARTLY CHILLED WITH WHOLLY CHILLED AND GRAY BODIES

38 In conducting this series of tests, bars were cast having only

one side chilled as companion bars to the all-chilled and gray bars, as seen by the second test, Tables 5 to 9. It will be a surprise to many to find that in all the tests, excepting the two of Set 14, the partly chilled bars are weaker than the all-chilled or white bars. A good view of these three companion bars is shown in Fig. 5, *K* being the partly chilled side.

39 The weakness of the partly chilled bars is due to internal strains and scattered amalgamation of the state of the broken carbon of the metals. Bars showing nearly every effect of rapid and slow cooling, and in no wise possessing the homogeneous blending of one character of grains, seen by the wholly white and gray, is well illustrated by *H*, *L*, Fig. 5.

40 All the partly chilled bars showed the chilled body interlacing the mottled, and the latter blending into the gray, Figs. 5, 6 and 7. This is generally considered to be a stronger section than those where a distinct line marks the separation of the white and gray, and causes conditions such as can still further increase the weakness of partly chilled castings. Designers should duly consider this factor, so as either to have a strong backing of the mottled and the gray, or to have the chilled side of the casting arranged in compression if practical, when strains or concussions of its work is brought to bear upon it, a feature in keeping with the tests on treatment of Table 10.

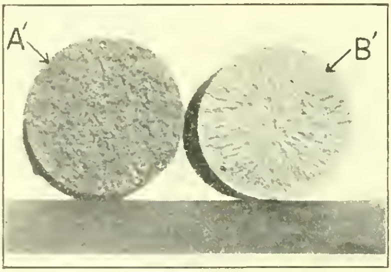

Fig. 8 Specimens of All Chilled and All Sand Round Bars Cast on End

COMPARISON OF STRENGTH IN ALL WHITE AND ALL GRAY IRONS

41 A feature of this paper worthy of consideration is the strength and deflection obtainable in strictly all-chilled or white iron. It is generally supposed that white iron is very much weaker than gray, and has very little if any deflection. By referring to Tests 7, 21, 30,

35, 44, 49, 54, 69, 82, 84 and 88, it will be seen that white iron can be obtained at least 75 per cent as strong as gray. White iron is the strongest with the crystals radiating from a center as at *M* and B,′ Figs. 6 and 8. The round bar excels the square in this form of structure.

SPALLING WEAKNESS OF CHILLED OR WHITE IRON

42 The chief evil of white iron lies in its strength being erratic, and easily spalled. It is believed that founders could greatly increase and control the strength of various grades of white irons and make them much more reliable.[1]

43 Numerous experiments were conducted to test the spalling weakness of white and gray iron and it was found that white bodies do not possess much over one-third the strength to resist spalling blows that exists in the gray or mottled of the same iron. It shows the importance of designing that portion of the casting subject to such blows to contain as far as practical gray or mottled iron.

HARDNESS TESTS OF ALL CHILLED, PARTLY CHILLED AND SAND-CAST TEST BARS

44 Table 12 gives Brinell and Scleroscope tests of three samples taken from each of the first three bars of Sets 12 to 19, a view of which is seen in Fig. 5. The Brinell depressions were produced by a $\frac{3}{8}$-in. ball loaded with 6000 lb. and the readings are the weight in kg. sustained by 1 mm. of area of the depression produced by the total load. This is the standard method of testing Brinell hardness. Both the Brinell and Scleroscope records are the averages of 4 to 6 tests on a sample.

45 The columns *H*, *I*, *J*, *K* and *L* give the tests of the surfaces indicated by the same letters shown in Fig. 5. Those who conduct these kinds of tests know that there is some variation of hardness over an area although it may not exceed 1 sq. in. The surfaces *H* had a variation of 3 to 7 points and *I*, 8 to 15 points, *J* about 6 points, while *L* had but 3 points, showing that a greater uniformity in hardness can be expected in all gray bodies than in mottled or chilled surfaces.

46 The table also shows that directly chilled faces, as *H*, are harder than those crystallizing over a sand surface caused by the heat-absorbing effect of a chiller, some distance from such points, as *I*. The excessive variation of the surface *I* is believed to be caused by the curved structure of the heat radiation lines, as they come to

[1] See foot-note, p. 871.

the surface at an angle, differing from the straight lines shown on the sides at *H*.

47 The spurious iron is on an average harder than the regular iron. The alloys appear to have a hardening effect as compared with the regular iron, or that having only ferro-manganese in it. The irregularity in the effect of the alloy is no doubt due to the variations in the temperature of the metal filling the molds, and brings about variations in hardness similar to creating an irregularity in the chill, strength, deflection and contraction of like irons.

CREDIT FOR PROFESSIONAL COÖPERATION

48 Nearly all the bars tested for records in this paper were cast at the Cleveland plant of the National Car Wheel Company, and

TABLE 12 BRINELL AND SCLEROSCOPE HARDNESS TESTS OF SPECIMENS, FIG. 4

Set No.	Class	*H*		*I*		*J*		*K*		*L*	
		Bri.	Scl.	Bri.	Scl.	Bri.	Scl.	Bri.	Scl.	Bri.	Scl.
12	*R*	394	65	348	59	179	39	326	55	185	39
13	*V*	377	63	358	60	227	41	403	60	199	41
14	*R*	417	66	403	58	185	38	386	61	175	38
15	*T*	419	68	427	56	211	41	412	58	186	40
16	*S*	452	69	412	59	224	40	443	60	191	42
17	*R*	358	62	390	56	189	39	317	47	173	37
18	*TV*	382	64	375	61	193	40	400	54	183	40
19	*TV*	442	66	422	54	189	41	417	57	179	38

tested by Mr. H. E. Smith, engineer of tests, assisted by Mr. G. E. Doke, both of the Lake Shore & Michigan Southern Railroad, Collinwood, Ohio. Assistance was rendered in making the bars by Messrs. H. E. McClumpha, general manager; J. D. Cunningham, plant manager; and Charles K. Logue, foreman of the wheel foundry. Some of the tests shown herein were made by Prof. John H. Nelson of the Case School of Applied Science. The hardness tests were made by Mr. Robt. R. Abbott, metallurgical engineer of the Peerless Motor Car Company; the analyses by Messrs. Crowell and Murray, chemists, both firms of Cleveland. The vanadium was furnished by Mr. George L. Norris, engineer of tests of the Vanadium Sales Company of America, and the titanium by Mr. Charles V. Slocum, general sales agent of the Titanium Alloy Manufacturing Company, both of Pittsburgh, Pa. All the test bars were made by the writer and tested under his supervision, who hereby desires to tender sincere thanks to all the above firms and gentlemen for having so kindly and ably assisted him in these researches.

BITUMINOUS COAL PRODUCERS FOR POWER

By C. M. Garland

ABSTRACT OF PAPER

The paper describes the apparatus and general arrangement of bituminous coal producers as designed for power. The scrubbing apparatus is described in detail, data given on its efficiency, and the amount of solid matter delivered in the gas. Data on the efficiency of the plant, composition of the gas, and operating costs, together with brief discussions on these items are also included. Figures for the first cost and operating costs at full load for a 1200-b.h.p. plant are given in such a way as to make them applicable to different conditions of fuel and load.

BITUMINOUS COAL PRODUCERS FOR POWER

By C. M. Garland, Camden, N. J.

Member of the Society

In the development of the power producer for the gasification of fuels containing above 12 per cent volatile matter, the manufacturers at an early date divided themselves on the question of the method of handling this troublesome constituent and proceeded with their developments along two diverging lines.

2 In one they sought to convert the condensible combustible constituent of the volatile matter into fixed combustible gases by drawing this product through either the whole or part of the incandescent fuel remaining after volatilization; in the other to separate the condensible portion from the permanent gases after these had left the generating chamber. The former group accordingly turned their energies to the development of down-draft and double-zone arrangements, while the latter bent their efforts toward the production of efficient up-draft generators and tar-handling apparatus.

3 It has been the fortune of the writer to observe the operation of a number of plants of the latter type and to analyze the results of the operation of others. It is the object of this paper to present some of the data accumulated, which are necessarily more or less fragmentary in character.

DESCRIPTION OF APPARATUS

4 The plants are all of two general types, suction and pressure, while the apparatus is essentially similar in each, varying principally in size and general arrangement. Fig. 1 shows a vertical section through the producer, scrubber and the water-sealed gas main, which is characteristic of the arrangement of all later plants up to about 1000 h.p. capacity. The pressure plant differs from the

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The American Society of Mechanical Engineers, 29 West 39th Street, New York. All papers are subject to revision.

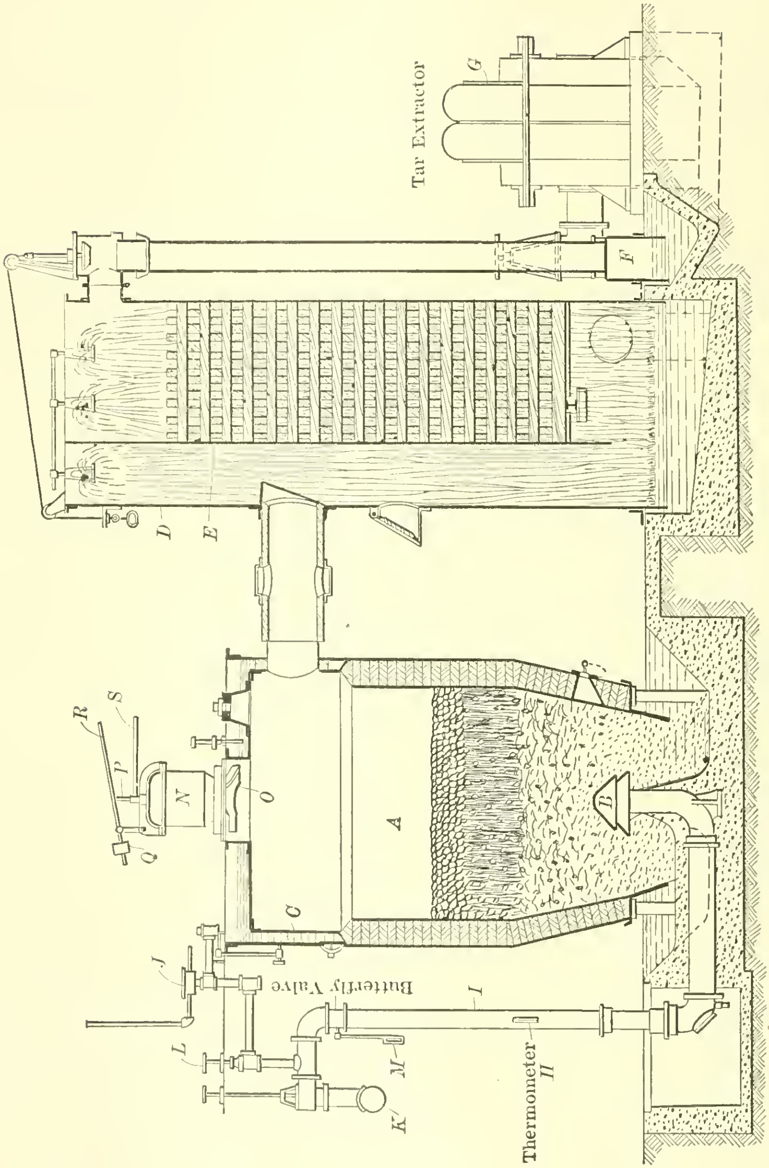

FIG. 1 SECTION OF GAS PRODUCER PLANT FOR POWER

suction plant by the addition of a fan type blower, frequently installed in duplicate, and a regulating holder. This latter in the earlier plants served as a large storage reservoir with capacity sufficient to keep the engines operating from 3 to 10 minutes in cases of emergency. It was also thought that this large capacity tended to insure greater uniformity in the composition of the gas supplied to the engines, so that the holders were placed in series with the engine and scrubbers. In more recent plants the size of the holder has been greatly reduced and in most cases floats on the line so that the gases do not pass through this piece of apparatus.

5 This change has been brought about partly by the fact that a large storage capacity is not required and in many places is undesirable. Also the mixing effect of the gases in the holder has proved a fallacy.

6 From Fig. 1 it will be noted that the producer *A* is of the water-sealed type, with central blast *B* and superimposed vaporizer *C*. The gases pass direct from the producer to the scrubber *D*, which is provided with a vertical baffle *E* from the scrubber to the water-sealed main *F*, and from this to the tar extractor *G*. This latter piece of apparatus is of the centrifugal type and is illustrated in Figs. 2 and 2a. The extractor has been in use a number of years and was brought out by Mr. F. V. Matton of the Camden Iron Works.

7 Referring to Fig. 2, the gas enters at *A* and meets a stream of water at *B*. The mixture flows upon the rotating vanes *C* and is discharged into the stationary vanes *D*. The water and a portion of the tar is thrown out against the casing *E* and follows this around to the drain *F* which discharges into the seal pit *G*. The gas leaving the stationary vanes *D* re-enters the rotating vanes *H* on the opposite side of the disk *I*. The gas here meets a stream of water from the nozzle *J* moving in the direction opposite to the gas which removes the remaining tar. The gas leaves at *K*.

8 The extractors are usually designed to deliver the gas under a low pressure and are built in more than one stage for the larger powers.

9 A portion of the steam generated in the superimposed vaporizer *C* in Fig. 1 is used to saturate the blast. The amount supplied is indicated by the temperature shown on the thermometer *H*, which extends into the blast pipe *I*. The steam pressure on the vaporizer is maintained constant by the back pressure valve *J*,

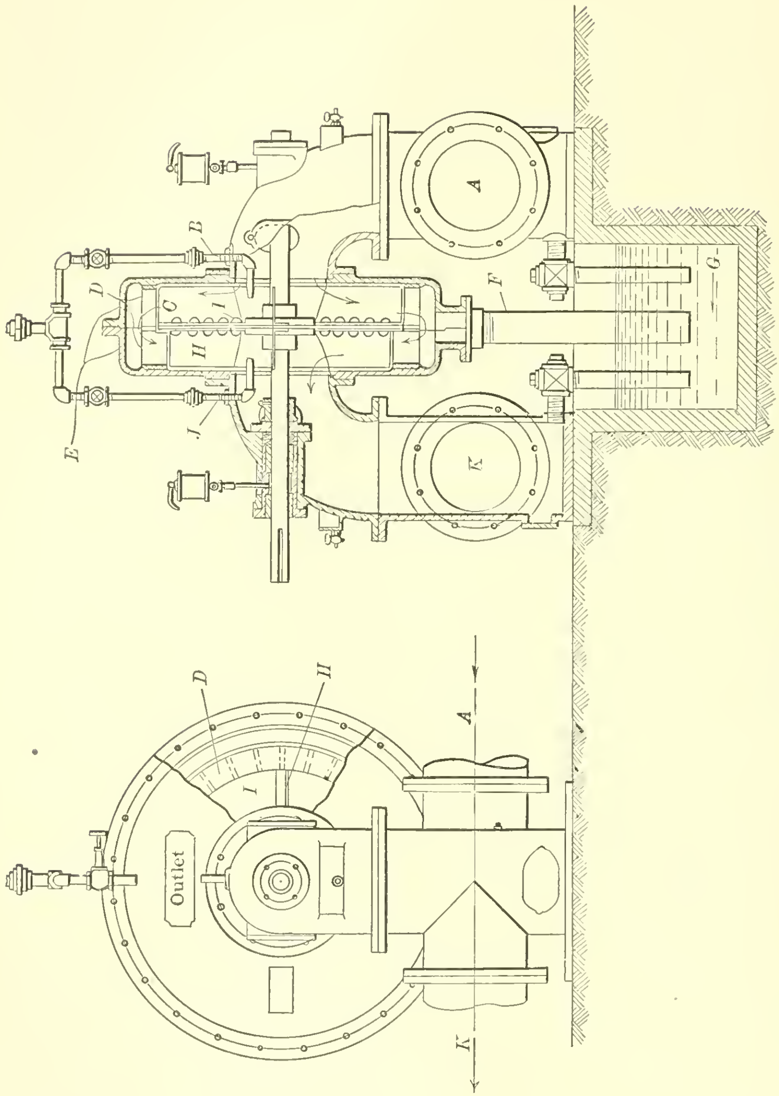

FIG. 2 175-H.P. TAR EXTRACTOR

while the air pressure on the main *K* is also constant. The valve *L* is therefore used to vary the amount of steam delivered to the blast. The butterfly valve *M* connects with the holder and regulates the amount of blast delivered to the producer. Changes in the position of this valve do not affect the relative proportions of air and steam. In more recent plants a thermostat located in the blast pipe operates a throttle valve in the steam line from the vaporizer in order to maintain a constant temperature of the blast.

10 The fuel is fed to the producer by the hand-operated centrifugal charging device *N*, which insures a very even distribution of fuel. This consists of the hopper provided with the ribbed charging bell *O*, which is rigidly mounted on the shaft *P* and held against its seat by the counterweight *Q*. When the fuel is charged the bell is lowered by the arm *R* and at the same time rotated by the arm *S*. Both arms are hand operated. After the fuel is charged, the counterweight *Q* causes the bell *O* to seat. A sliding cover closes the top of the hopper which prevents the escape of gas while dropping a charge of fuel.

11 With this brief general description it will not be necessary to describe a number of individual plants. In order, however, to indicate the extent and variety of the work, Table 1, giving the equipment, service, load conditions, etc., has been prepared from a number of representative plants operating on different fuels.

THERMAL EFFICIENCY OF THE PRODUCER

12 The efficiency depends to a certain extent upon the amount of volatile matter contained in the fuel. For fuels containing as high as 30 to 50 per cent of volatile matter, the thermal efficiency based on the higher heating value of the gas is about 66 per cent, while the efficiency based on the effective heating value of the gas is ordinarily 5 per cent lower than this, or 62.7 per cent. Where the volatile matter does not exceed 20 per cent the efficiency is somewhat higher, and 70 per cent based on the higher heating value of the gas is an average figure. The lower value is approximately 66.5 per cent.

13 In plants of the present type, however, thermal efficiency is not necessarily of paramount importance, for more often it is a question of the adaptability of the producer to a given fuel or to several fuels and of continuity and reliability of operation.

TABLE 1 BITUMINOUS COAL AND LIGNITE PLANTS

Plant	*A*	*B*	*C*	*D*	*E*	*F*	*G*
Type of plant	Suction	Suction	Pressure	Pressure	Suction	Suction	Pressure
No. of producers	1	1	3	2	2	1	2
No. of tar extractors	1	1	2	2	1	1	2
Inside diameter of producers, ft.	7	6	8	6	7	5	7
Spare producers	0	0	1	1	0	0	0
Spare tar extractors	0	0	1	1	0	0	1
Size of holder, cu. ft.	...	...	5000	5000	...	...	15,000
Rated capacity of plant, b.h.p.	225	140	900	190	500	125	500
Character of service	Light and power	Light and power	Light and power	Light and power	Mill	Pumping	Light and power, gas for heating
Years plant in operation	2	2½	1½	6½	3	2	5
Hours per day in operation	11	18–24	24	...	10–24	10–24	24
Days per week in operation	6	6½	6½	...	6½	6½–7	6
Load factor, per cent	About 100	...	Variable	...	Variable	About 100	About 100
Character of load	Uniform	Variable	Variable	Variable	Variable	Uniform	Uniform
Fuel used	Illinois coal	* Various	Pocahontas	Pocahontas	Lignite	Lignite	Pocahontas New River
Proximate analysis fuel:							
Fixed carbon, per cent	55.30	32.10	73.70	71.40	16.4	29.39	...
Volatile, per cent	35.47	47.00	17.7	21.70	51.2	39.84	...
Moisture, per cent	3.00	3.90	1.6	2.20	25.7	23.11	...
Ash, per cent	6.23	17.00	7.0	4.70	6.7	6.78	...
B.t.u. per lb.	13,500	11,000	14,700	14,700	8,500	...	14,700

* Texas bituminous coal used when determining solid matter in the gas.

COMPOSITION OF THE GAS

14 The composition of the gas and the heating value are comparatively uniform where proper attention is given to the operation of the producers. Table 2 shows the gas analyses taken on a seven-day test, which was made on the plant marked *C* in Table 1. The calorific values by the calorimeter, taken every two hours, are plotted in Fig. 3. The average higher heating value of the gas was 144.1 b.t.u. per cu. ft. at 62 deg. fahr. and 30 in. mercury pressure. The average lower heating value was approximately 136 b.t.u. under

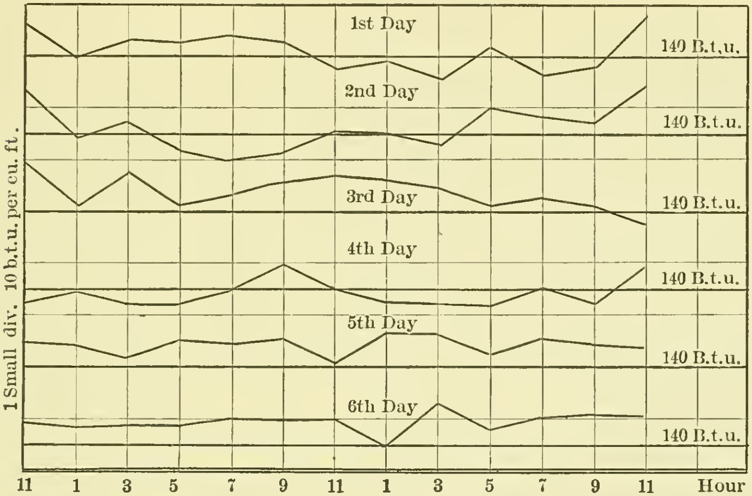

Fig. 3 Heating Value (Higher) of Gas for 144 Hours Continuous Run, Plant *C*

the same conditions of pressure and temperature. For fuels containing greater percentages of volatile matter there is a tendency toward an increase in the calorific value of the gas due to the increase in hydrocarbons. With the lignites, for example, the higher heating value of the gas may average as much as 155 b.t.u. per cu. ft.

VOLUME OF GAS GENERATED

15 The volume of gas generated per pound of coal depends upon the composition of the coal and the condition of the fuel bed. In the seven-day test (Table 2), the volume of the standard gas generated per pound of run of mine Pocahontas coal was approximately

71.5 cu. ft. For lignite the volume of standard gas varies between 36 and 40 cu. ft. per lb.

TABLE 2 GAS ANALYSES, SEVEN-DAY TEST, PLANT *C*

Day	CO_2	O_2	CO	H_2	CH_4	Day	CO_2	O_2	CO	H_2	CH_4
1st*	5.6	0.2	24.1	7.65	4.5	4th	5.0	0.4	23.6	10.80	2.3
	4.0	0.2	27.6	9.83	3.3		4.0	0.2	25.4	10.52	3.3
	6.8	0.4	22.6	10.36	2.0		4.6	0.2	24.2	9.60	3.3
	5.8	0.2	23.6	13.8	2.4		4.2	0.4	25.1	11.7	2.6
							4.7	0.0	25.8	12.0	2.6
2d	8.2	0.3	17.5	11.3	3.4		6.0	0.3	20.8	10.53	2.1
	5.2	1.2	21.8	14.00	2.5						
	4.5	0.2	25.9	13.40	2.2	5th	3.5	0.2	25.5	9.50	2.6
	4.8	0.2	25.5	11.60	2.4						
	4.6	0.4	26.3	10.60	2.4	6th	4.2	0.2	24.7	9.15	3.5
	7.9	0.7	18.7	12.43	3.0		5.0	0.3	24.7	9.40	3.8
	5.4	0.3	24.5	8.50	2.2						
	7.2	0.2	19.6	10.53	3.6	7th	5.0	0.2	24.2	9.15	3.4
	7.3	0.1	20.1	10.30	2.9		4.9	0.3	24.8	11.03	2.0
							4.4	0.3	25.7	12.00	2.6
3d	7.8	0.4	18.8	10.9	3.8		4.9	0.3	25.0	12.0	2.0
	5.2	0.4	24.0	11.4	2.6		5.3	0.4	25.3	10.8	2.0
	5.5	0.2	22.5	8.93	3.4		4.5	0.3	25.6	9.8	2.2
	5.5	0.2	22.5	8.93	3.4						
	5.2	0.4	23.6	9.50	2.9	8th*	4.0	0.2	26.	9.25	2.40
							5.5	0.3	24.3	11.45	2.0
							5.0	0.3	24.3	11.53	2.0

* One-half day only.

TABLE 3 TESTS ON CLEANLINESS OF GAS DELIVERED BY TAR EXTRACTORS

Plant	No. of Determinations	Fuel	Per Cent Volatile	Grains Solid Matter, Cu. Ft.	Efficiency Extractor, Per Cent
A	1	Illinois Coal	31.0	0.0150	96.0
B	2	Texas bituminous	47.0	0.0062	99.5
C	11	Pocahontas	17.7	0.0163	98.5
D	1	Pocahontas	21.7	0.0585	93.5*
E	2	Texas lignite	51.2	0.0050	99.5
F	2	Pocahontas	22.8	0.0227	....

* Tar extractors operated at 1000 r.p.m., instead of 1500 r.p.m. rated speed. Dry scrubber used beyond tar extractors in this plant; solid matter in gas leaving dry scrubber 0.0421 grains per cu. ft.

CLEANLINESS OF THE GAS

16 A large number of tests have been made on the cleanliness of the gas delivered by the tar extractors in the above plants. The

results of these determinations are given in Table 3. From these it will be seen that the amount of solid matter in the gas has been reduced to a very small quantity and averages 0.0206 grains per cu. ft. of standard gas. The efficiency of the tar extractor is given also in several cases. This was taken as the ratio of the weight of solid matter in the gas leaving the extractor, to the weight of solid matter in the gas entering the extractor, multiplied by 100.

17 The determinations were made by drawing samples of the gas through three thicknesses of filter paper on which the solid matter was deposited. In most cases simultaneous samples were taken from the entering and exit sides of the extractor. These samples were measured by calibrated meters.

18 It will be seen from the results of Table 3, that the average weight of solid matter per cubic foot of standard gas is not sufficient to cause trouble in engines of ordinarily good design. Experience seems to indicate that with 0.03 grains of solid matter per cu. ft. in the gas, the engine valves require cleaning once in two or three weeks. There is no trouble from this source in plants that are properly operated and the cleaning of the valves would not be considered a hardship.

19 In making the above determinations, no attempt was made to separate the tar from the dust, as this was not deemed of sufficient importance.

HANDLING OF THE TAR

20 In the earlier plants considerable difficulty was experienced by the tar accumulating in the scrubbers and pipe lines, which caused frequent shutdowns. In almost every case this trouble was due to lack of experience on the part of the builders in designing these parts, and to the operators who failed to take proper precautions and profit by their first troubles.

21 At the present time and for the more modern plants it can be safely said that trouble from this cause has almost entirely ceased. The water-sealed gas main has solved the piping difficulty, while refinement in the design of the other parts and close attention to detail has accomplished the same effect for these.

22 In so far as the yield of tar is concerned, there are but three objections that can be urged against this:

a Loss in efficiency of the plant due to the removal of a combustible constituent from the fuel.

b The expenditure of power in the driving of the tar extractor for the removal of this constituent.

c Difficulties in the disposal of the constituent.

23 Taking it for granted that the tar in every instance can be disposed of satisfactorily, as it can be, the answer to these objections is that it is entirely a question of economy and if it does not pay to handle this element then bituminous coal is either not the fuel to use, or a producer plant is not the kind suitable to the conditions.

24 The magnitude of the above items is fairly well known. The loss in thermal efficiency (*a*) varies from 12 per cent for fuels containing from 15 to 20 per cent volatile matter to 17 per cent for fuels containing above or near 30 per cent of volatile matter.

25 The amount of power (*b*) required to drive the tar extractor depends upon the nature of the tar produced. With lignites, for example, which produce a thin yellowish tar resembling very nearly a heavy oil, the power required is at least 25 per cent less than the amount required for bituminous coals.

26 For bituminous coals this power varies from 5 per cent of the power of the plant in a plant of 100 b.h.p. to about 3.5 per cent for a plant of 1000 b.h.p., and it is believed that this figure will be reduced almost one-half in the near future.

27 As to the difficulties in the disposal of the tar (*c*), there is in some instances a ready market for the tar product so that this may be disposed of to advantage. In other cases where boilers are in service, it can be burned without difficulty under these boilers.

28 The usual method of handling the tar is to place the extractor over a pit containing water into which the mixture of tar and water from the extractor is discharged. The pit is arranged so that the tar may be skimmed from this into a barrel or receiver. Where a receiver is used it is provided with an air tight cover, and when the receiver is filled the cover is put in place and either steam or air under pressure placed above the tar, which forces it through piping to the point of disposal. Where the tar is thick and heavy, it is necessary to provide the receiver with a steam coil to keep the tar in a fluid condition.

THE FUEL REQUIRED

29 It can almost be safely said that any fuel can be used in any well designed producer of the up-draft type. If the fuel can not be used the probabilities are that the fault is either in the operation or in the design of the producer. The reason for this is that there are

but three fundamental requirements for the successful gasification of a fuel. These are, uniform distribution of the blast, uniform distribution of the green fuel and uniform removal of ash. These three are essentially one as they are so closely related and interdependent that they reduce to uniform distribution of the blast.

30 When these requirements have been met in the design of the producer, the writer has never found a fuel that could not be gasified, at much higher rates and with much less labor than is considered possible by the majority of engineers.

31 An example in which the difficulty lies in the operation of the producer is illustrated in the case of the Texas bituminous coal, Plant *B*, Table 1. This was a highly caking coal and the operators of the producer stated that it was impossible to use this fuel in the producer. After observing the operation for a few hours it was found that the difficulty was due to the caking properties. When full hoppers of fuel were dropped upon the hot bed the fuel fused into a solid mass through which the blast could not penetrate. By charging a half hopper of fuel every 15 minutes in place of a full hopper every 30 minutes, there was no further difficulty.

32 The analyses of Table 1 indicate the variety of fuels that are being used successfully, and to these can be added Hocking Valley, Pittsburgh run of mine, Youghiogheny, etc.

RELIABILITY

33 Referring to Table 1, from the last reports obtained about one year ago, Plant *D* had been in successful operation for over five years without a shutdown and without having the fire drawn from the producers.

34 The last reports from Plant *A* indicated highly satisfactory results and no shutdowns, the engine pulling full load and a large portion of the time as much as 15 per cent overload. Fig. 3 shows the heating value of the gas taken every second hour for 144 hours continuous running, while Table 2 shows the analyses of the gases taken over the same period, from Plant *C*, Table 1. Two 8-ft. producers were in operation for the full period. The engines pulled an average load of 568 kw. with a maximum of 640 kw. for 1 hour, and a minimum of 405 kw. for 1 hour. The coal consumption was 1.78 lb. per kw-hr. at the generator terminals, including a 24-hr. standby, and the rate of gasification was about 10 lb. of coal per sq. ft. of fuel bed per hour. The fuel used was Pocahontas run of mine.

35 Plant *F* is used for irrigation work where the load is inter-

mittent. At times it operated at full load 24 hours per day and at other times only 10 hours per day. Results have been entirely satisfactory. The same is true of *E*, which operates a cotton meal mill. This is one of the most successful lignite plants. The latest reports state that lignite screenings, costing less than 50 cents per ton, are being used successfully.

36 Plant *G* showed a fuel consumption of 1.65 lb. of coal at full load per kw-hr. at the generator terminals, 1.89 lb. at three-quarter load and 2.2 lb. at one-half load, when operating on Pocahontas coal. On New River slack the coal per kw-hr. is approximately 1.6 lb. at about full load.

37 Plant *B* was reported unsatisfactory. It was found on investigation that for two years the plant had been operated from 18 to 24 hours per day and the station logs showed that the engine had pulled a 25 per cent overload for about 2 hours during the peak every evening. Any fuel that could be picked up in the open market was used, and the man that operated the producers also fired two boilers for running about 400 h.p. in high-speed steam engines.

PRODUCER PLANT COSTS

38 The cost of producer plants and of operating are by no means fixed quantities, so that it is very difficult to give figures that are general and that can be safely applied to any and every case. Each plant requires individual consideration in order that no mistakes or misunderstandings may arise. It is therefore with some hesitation that the following figures are given.

FIRST COST

39 The first cost depends upon

a The service or load conditions, that is, continuous, intermittent, or variable load, and the magnitude of the load. These determine the necessity for duplicate or spare apparatus and the number of units into which the plant should be divided.

b Upon the design of the producer. With a given fuel one type of producer may gasify 50 per cent more fuel than another type, or one type may be capable of continuous operation, while still another may require a light load during the period of the removal of ash.

c Upon the method of generating steam for the blast. That is, whether or not the producer generates its own steam

supply or requires that this should be generated in separately fired boilers, either direct fired or exhaust fired. Where the producer generates its own steam supply the first cost of the producer plant is, as a rule, much less expensive than the installation of either direct or exhaust-fired boilers.

d Upon the characteristics of the fuel. One fuel may be gasified at a much higher rate than another, thus reducing the size of the producers required.

e Upon the percentage of ash. With low percentage a plain water-sealed producer is satisfactory. With percentages above 12 or 15 per cent a rotating table and cone bottom become desirable in order to reduce the labor costs.

f Upon the scrubbing apparatus required. This depends upon the amount of volatile matter in the coal, and the characteristic of the products resulting from the volatile matter which appear in the gas.

g Upon the method of handling the coal.

h Upon local conditions.

OPERATING COST

40 The operating costs are very intimately connected with the first cost and depend upon

a The character of the fuel. Some fuels require a greater amount of labor than others.

b The design of the producer. A properly designed producer will require much less labor than a poorly designed producer when operating on a given fuel at a given rate of gasification. In some instances small changes in the arrangement of the admission of the blast to the producer have reduced the labor required to operate at least 50 per cent.

c The amount of ash contained in the fuel.

d The coal-handling machinery.

e Facilities for handling the tar.

f Supervision. In every instance where the plant is under the direction of a man that understands the apparatus and has given his thought to the operation, the operating costs are greatly reduced.

g Local conditions.

41 In order to analyze the different costs and indicate their

approximate magnitude for pressure plants ranging in size from 500 to 1500 b.h.p., a proposition will be assumed wherein it is required to develop from bituminous coal of known properties, approximately 1200 net b.h.p. in excess of the power required to operate the producer auxiliaries.

42 It will be assumed that the load conditions are such that three units are desirable and the costs will be based on full load operation 365 days per year, 24 hours per day. From these costs the effect of various load factors may be investigated.

43 The following assumptions will be made:

Coal.............13,500 b.t.u. per lb. calorimeter determination or high	value
Cost per ton delivered	\$1
Per cent volatile matter	32
Per cent ash	8
Efficiency of the producer based on the effective heating value of the gas, per cent	62.7
Effective b.t.u. required by the engines per b.h.p. at full load	10,500
Effective b.t.u. per lb. of coal $\frac{13500 \times 62.7}{100}$	8465
Lb. coal per b.h.p-hr. $= \frac{10500}{8465}$	1.24
B.h.p. required for tar extractor	30
B.h.p. required for fan blower	5
B.h.p. required for scrubber water pump	5
Total auxiliaries	40
Total b.h.p. required	1240
Total lb. coal per hour $= 1240 \times 1.24$	1538
Area of fuel bed required at 10 lb. gasification, sq. ft.	153.8
Three producers 8 ft. inside diameter will be required. These would have a continuous overload capacity of 25 per cent, and 50 per cent for three hours	
Area of fuel bed of each producer, sq. ft.	50.26

44 Each producer should be of the water-sealed type for continuous operation since the fuel is a bituminous coal of medium grade containing a fair amount of ash. The steam for the blast may be obtained by the use of a superimposed vaporizer, a vaporizer placed between the producer and the scrubber, an exhaust boiler or an independently fired boiler. The latter is very uneconomical and has a high initial cost, so that it is not used in power work at the present time. The exhaust boiler is economical provided there is no other use for the steam that may be thus generated. The first cost is, however, high, and as in many cases it must be located at a

distance from the producers and requires more or less attention, its use in plants of this size and for this purpose is hardly justifiable.

45 The vaporizer or boiler between the producer and scrubber, while an excellent arrangement for anthracite plants, is unsuitable for bituminous coal plants on account of the solid matter that is carried in the gas.

46 The superimposed vaporizer therefore remains as the last choice. This is low in first cost and while it absorbs a certain amount of radiant heat from the fuel bed, which could otherwise be utilized, it is convenient, requires little or no attention and essentially no repairs, so that for small and medium sized bituminous plants it is the most economical method of generating steam for the producers, and will therefore be selected.

47 To each producer a static scrubber will be connected, as shown in Fig. 1. These scrubbers will in turn connect to a water-sealed gas main. Since the plant is to operate continuously, two tar extractors and two fan blowers will be required, one of each for a spare. The tar extractors and fan blowers should be driven by electric motors direct connected; 35 or 40-h.p. motors will be required by the former, while 5 or 7½-h.p. motors will be required for the latter. The coal-handling apparatus will consist of a 30-ton coal bin located above the second producer with spouts to the coal hoppers of each producer. A track bin will be located near the producer house and an elevator used for delivering the coal from the track bin to the 30-ton coal bin above the producers.

48 The ash removed from the water seals of the producer will be loaded into a small car which may be hoisted into either a railroad car or ash wagon by means of a block and tackle or an air lift.

49 The building will be of steel frame construction with corrugated iron sides. A charging platform will be built around the producers.

50 For an equipment of this nature, the cost of the producers and auxiliary apparatus erected on the foundations, including the charging platform but not including freight, will be approximately:

Per b.h.p. of the engine	$11.20
Foundation per b.h.p. of the engine	0.48
Coal handling apparatus per b.h.p. of the engine	1.42
Building 50 ft. x 45 ft. per b.h.p. of the engine (not including land)	2.25
Total	$15.35

51 The operating costs[1] may now be taken as follows:

Interest, depreciation, taxes, insurance at 13 per cent per annum per b.h.p-hr. (8760 hr. per yr.), cents..............................0.02280
Maintenance and repairs, this may be taken at $1\frac{1}{2}$ per cent of the first cost per annum, cents.................................. 0.00270

52 The item of supplies is a variable one and depends somewhat upon the behavior of the fuel. If it is a clinkering fuel the cost of bars for poking in itself may amount to quite an item. The total should not amount to over $200 per annum for average conditions, or 0.00185 cents per b.h.p-hr.

53 Labor is also a variable quantity, depending upon the behavior of the fuel, upon the management and upon the amount and kind of coal, ash and tar handling apparatus installed. In the case of the present plant, and with a fairly good fuel, three men per shift of 12 hours should handle the plant with ease.

54 The price for labor varies with the location, but $3 per day for the chief operator and $2 per day for his five assistants is ample. This makes a total of $4745 per year, or $0.0437 b.h.p-hr.

55 The cost of fuel has been taken at $1 per ton and at full load the coal per year will be $\frac{1538 \times 8760}{2000} = 6745$ tons or $6745, or 0.062 cents per b.h.p-hr.

56 We have therefore

	Per B.h.p-hr.
Interest, depreciation, taxes, etc.	0.02280 cents
Maintenance and repairs	0.00270
Supplies	0.00185
Labor	0.04370
Fuel	0.06200
Total	0.13305 cents

The total cost of operating the producer equipment at full load is 0.133 cents per engine b.h.p-hr.

57 If it is assumed that the gas generated has an average low calorific value of 136 b.t.u. per cu. ft. of standard gas, $\frac{8465}{136} = 62.2$ cu. ft. will be generated per lb. of coal, and $\frac{10500}{136} = 77.2$ cu. ft. will be required per b.h.p.

[1] Computations have been based on the brake horsepower of the engine and on coal at $1 per ton of 2000 lb. This basis would seem to make the figures most easily applicable to different conditions of load and fuel.

58 From the above 1000 cu. ft. of 136 effective b.t.u. gas will cost 1.72 cents. This figure, as above noted, does not include the cost of land for buildings, freight, nor the cost of scrubber water, which in many cases is obtained at the cost of pumping.

59 From the above figures the cost of power for any given load factor may be obtained and for any given cost of fuel. The power required by the producer auxiliaries remains practically constant, also the fixed charges and labor, unless in the case of the latter the load factor is sufficiently low to dispense with one producer operator per shift. The only variable is therefore the amount of coal used which may be determined from the number of hours of operation and the heat consumption of the engine at different loads, on the assumption that the producer efficiency is constant at all loads from 25 per cent to 1.25 per cent.

FUTURE DEVELOPMENTS

60 Plants of the type described have proved reliable and economical in practically every case. Particularly is this true for plants operating on poor fuels, like the lignites, and plants operating on high priced fuels. The economy obtained depends, however, to a large extent upon the intelligence displayed in the operation and in the design of the plant.

61 The future for these plants is also promising, as more economical results are now recognized as attainable, through the following improvements which reduce the first cost of the plant and also the operating costs:

a Increase in the rate of gasification.

b Decrease in the power required to drive the cleaning apparatus.

c Utilization of waste heat.

Increase in the rate of gasification has been made possible by a careful study of the effect of the distribution of the blast on the operation of the producer.

62 A number of years ago the writer demonstrated on a small anthracite producer in the mechanical engineering laboratory of the University of Illinois, that certain fuels could be gasified at rates as high as 40 lb. per sq. ft. of fuel bed per hour without difficulty. The results of one of these tests were presented to the Society at the Annual Meeting in 1909.[1] Later while operating on lignite in Texas which produced a very fine ash and caused considerable trouble in

[1] Testing Suction Gas Producers with a Koerting Ejector, Trans. vol. 31, p. 831.

the ordinary central blast producer, the prime reason for the satisfactory gasification of one fuel at a very high rate of gasification and the failure in the gasification of another fuel at the same rate, was most clearly and forcibly demonstrated.

63 These two experiences, with a study of the operation of a large number of producers on bituminous, semi-bituminous, lignites, anthracites and semi-anthracites, have led to the complete realization of the three fundamental requirements that must be met in the successful gasification of all fuels as previously set forth, viz.

a Uniform distribution of the green fuel.
b Uniform removal of ash.
c Uniform distribution of the blast.

64 A study of the producers on the market today will reveal the fact that there are few if any that meet all of these comparatively simple requirements. A few have partially done so and have proved successful at low rates of gasification, or at high rates on certain fuels. The Mond producer illustrates the latter, although this fails entirely to meet the first and second requirements, but very nearly meets the third, which is the most important and the end desired.

65 The Taylor producer illustrates the former, for as it was designed it failed to meet requirements *b* and *c*, and, while successful for gasification of 10 lb. and under, was never capable of higher rates on average fuels. A change in accordance with the above requirements demonstrated that a gasification of 15 lb. was accomplished with the same ease as 10 lb. had been accomplished in the past, when operating on a poor grade of anthracite.

66 From this study and investigation it has become apparent that average fuels can be gasified at rates from 50 to 150 per cent greater than the present rating of producers (9 to 10 lb. per sq. ft. of fuel bed per hour), and with no increase in labor. This means a great reduction in the first cost of producer plants and also in the operating costs. Furthermore, the same principles produce the same results in large producers as in small producers, so that it is just as practicable to build a producer of large as of small diameter, while the labor per square foot of fuel bed required in the operation of the producer, the first cost, and operating costs are greatly reduced. A producer 9 ft. in diameter inside the lining, having an area of 63.6 sq. ft., requires less labor to operate than two producers 6 ft. in diameter (area 56.5 sq. ft.), while the quality of the gas is more uniform than that obtained from one of the smaller units. The

same is true of the producer $10\frac{1}{2}$ ft. in diameter, which is easier to operate than two producers 7 ft. in diameter. It is, however, true that the gas from two smaller producers will probably be more uniform in quality than the gas from one large producer. In any case where continuous operation and uniform condition are essential, at least two units should be installed.

67 The writer's experience would indicate that producers up to 15 ft. inside diameter are practical.

68 The power required to drive the cleaning apparatus has previously been referred to (Par. 26).

69 Utilization of the waste heat is an item that has received some attention in the past, but not as much as it warrants. As a rule, the average gas plant is extremely wasteful of heat. About 12 per cent of the heat in the fuel is thrown away in the scrubber water, while about 60 per cent is thrown away in the cooling water to the engine cylinders and in the exhaust. These last two quantities are available for steam raising in the bituminous coal plant. Approximately $2\frac{1}{2}$ lb. of steam can be generated per b.h.p. of the engine. Where there is a fairly uniform load and a demand for this steam, it can be obtained at a comparatively small cost and when credited against the cost of gas at the same rate as the cost of steam by direct firing, reduces the cost of gas from the plant from 12 to 20 per cent. If there is no demand for steam for heating or other purposes it may be used for the generation of power either in engines or turbines.

70 In the case of the 1240-b.h.p. plant just considered, 3100 lb. of steam can be obtained from the engine exhaust and jackets per hour. The exhaust boilers would cost erected, including foundations, about $2000.

71 For good economy the exhaust boilers should be of the low-pressure self-contained type, generating steam under about 5 or 10 lb. pressure. The heating surface should be approximately twice the amount per b.h.p. as that used in direct-fired boilers. It should not, however, be sufficient to reduce the temperature of the leaving gases below 220 deg. fahr., unless a cast-iron boiler is used.

72 Boilers for this purpose can be made practically automatic in operation and as a rule can be attended by the engine room operators, so that there is essentially no additional operating cost involved.

73 The interest, depreciation, repairs, maintenance, etc., on $2000 at $14\frac{1}{2}$ per cent per annum is $290, or 3.31 cents per hour.

The steam if generated in a small direct-fired boiler would cost about 9 cents per 1000 lb. when using coal at \$1 per ton. The credit for steam is therefore $3.1 \times 9 - 3.31$ cents per hour, or 0.0198 cents per b.h.p-hr. The cost of operating the producer equipment per b.h.p-hr. would be therefore $0.133 - 0.0198 = 0.1132$ cents. The cost of gas per 1000 cu. ft. would be 1.47 cents.

THE PRESENT STATUS OF THE DIESEL ENGINE IN EUROPE, AND A FEW REMINISCENCES OF THE PIONEER WORK IN AMERICA

By Rudolph Diesel, Munich, Germany

Honorary Member of the Society

There have been so many publications recently, especially during the past year, on the construction of the Diesel engine and its various types, that it is hardly possible to give any fresh information on this subject. I propose, therefore, to admit as generally known the working principle and construction of my engine and to discuss only questions of general importance.

Since its first appearance in 1897, many Diesel engines have been built in all industrial countries and it has proved reliable when properly constructed. The thermal or indicated efficiency now reaches 48 per cent in this engine, and the effective or brake efficiency in some cases 35 per cent of the heat value of the fuel.

Fig. 1 shows the heat utilization for 1 b.h.p-hr. in the different kinds of prime movers now known, and Fig. 2 shows a comparison of working and test results of steam plants, gas plants and Diesel engine plants.

The Diesel engine converts the heat of the natural fuel into work in the cylinder itself without any previous transforming process, and utilizes it as far as the present standard of science permits; it is, therefore, the simplest and at the same time the most economical prime mover. The working process for both the four-stroke cycle and two-stroke cycle engines is shown in Fig. 3, and indicator diagrams in Fig. 4.

The success of the Diesel engine is not due to constructional improvements or alterations of older types of engines, but to its

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Address given at a meeting of The American Society of Mechanical Engineers, New York, April 30, under the auspices of the Gas Power Section of the Society, at which honorary membership was conferred on Dr. Diesel.

new principle of the internal working process. A further reason is that the Diesel engine has broken the monopoly of coal, and has solved the problem of using liquid fuel for power production in its simplest and most general form. It has become for all liquid fuels what the steam engine and gas engine are for coal, but in a much simpler and more economical way. The truth of this statement was strikingly proved at the Turin exhibition of last year, where a steam

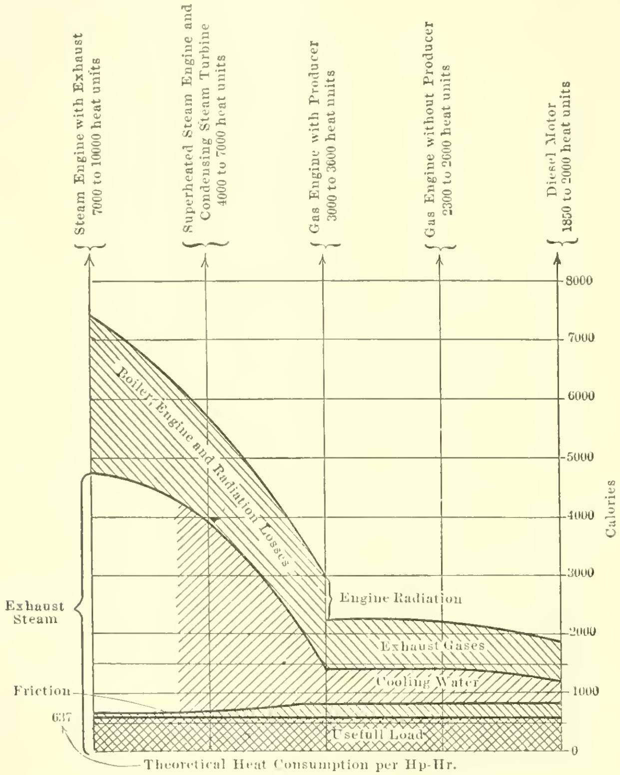


FIG. 1 COMPARATIVE HEAT UTILIZATION OF STEAM, GAS AND DIESEL ENGINES

turbine and a large Diesel engine, both made by Franco Tosi of Milan and set up on the same stand, were worked together with the same liquid fuel. The boilers belonging to the plant were fitted with Koerting nozzles for burning crude oil. The difference between the two plants was, therefore, that for the working of the steam engine there had to be provided the whole boiler plant with its chimney, fuel supply apparatus, feed pumps and purification plant

for feedwater, and steam piping; and the condensation plant with auxiliaries and an enormous water consumption. The steam plant showed a final result of two and one-half or more times the fuel per horsepower per hour required by the Diesel engine standing beside it. The latter, being an entirely independent engine without any auxiliary plant, took up its crude fuel automatically and consumed it direct in its cylinders without any residue or smoke.

UTILIZATION OF NATURAL PRODUCTS

Thus the Diesel engine can double the resources of mankind as regards power production, and has made new and hitherto unutilized products of nature available for motor power. The Diesel engine has thereby exercised a far-reaching influence on the liquid fuel industry, which is at the present time improving more rapidly than was previously conceived possible. This is not the place to discuss this matter in detail, but I wish to mention that, owing to the interest which petroleum producers have taken in this important question, new petroleum sources are continually being developed and new oil districts discovered. Moreover, it has been proved by recent geological researches that there is probably on the globe not only as much but even more liquid fuel than coal, and also that it is more conveniently distributed as regards its geographical position. These facts, which are indisputable, have gradually silenced those who objected to too great a development of the Diesel engine for fear of insufficient stores of liquid fuel.

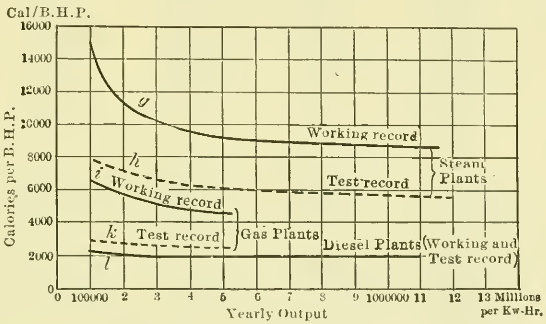


Fig. 2 Comparison of Working and Test Results for Steam, Gas and Diesel Engines

That the auxiliary industries of petroleum production are also considerably influenced is shown by the great increase which the

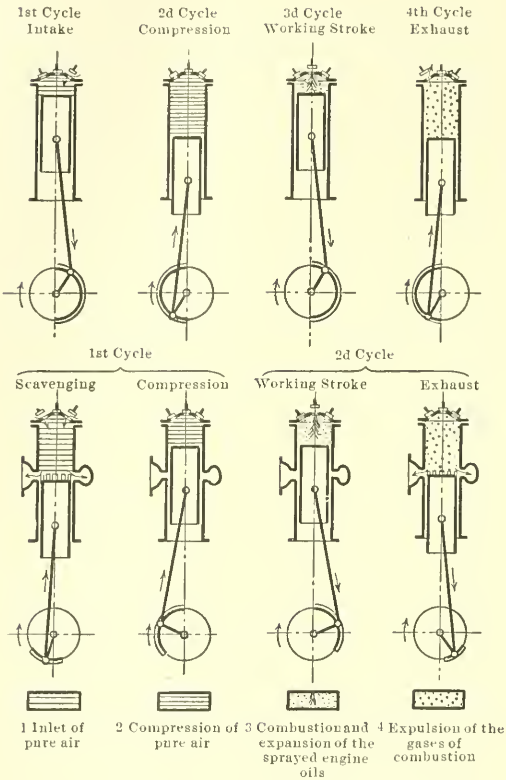


Fig. 3 Working Process of Four-Cycle and Two-Cycle Engines

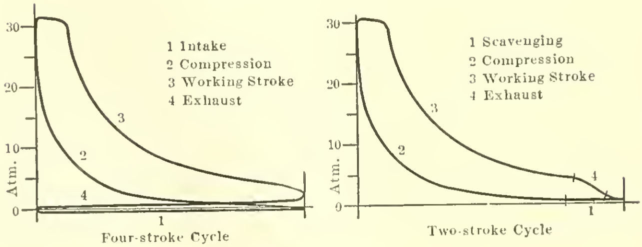


Fig. 4 Indicator Diagrams of Four-Cycle and Two-Cycle Engines

transport industry for liquid fuel has experienced in recent times, especially in the great development of tank vessels, which are, or will be, mostly driven by Diesel engines.

But with all this, the influence of the Diesel engine on the world's industries is not exhausted. As early as the year 1899, I utilized in my experimental engine the by-products of coal distillation and coke plants, such as tar and creosote oils, with the same satisfactory results as with natural liquid fuels, but at that time the quality of these oils was generally too inferior for their use in the Diesel engine, and it was, moreover, subject to continual variations. It is only in

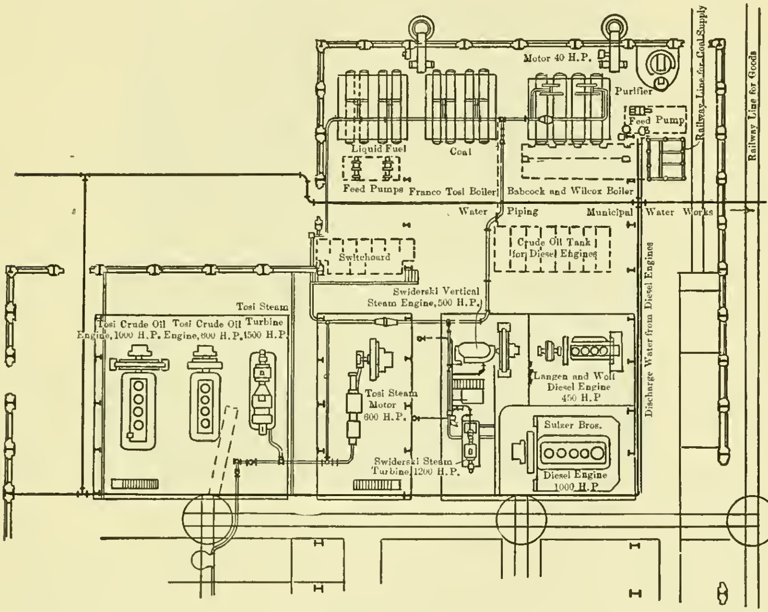


Fig. 5 Ground Plan of Power Plant at Turin Exhibition

recent years that the chemical industries interested in the matter have, by improved methods of fractioning and refining, combined with more careful selection of the material, succeeded in supplying fuel of a constant and regular quality without the drawbacks of the crude tar oils used previously. These products, the tar and tar oils, are thus definitely brought into the sphere of activity of the Diesel engine.

This fact is not so important in the United States because of its

richness in natural oil, but it is for European countries, especially those countries not having an oil production of their own. It may be of interest to state, for instance, that the tar production of Germany is sufficient for more than five millions of horsepower-hours per year, which means about one and three-quarter millions of horsepower running 300 days for ten hours each all the year. In case of war and the cutting off of the supply of foreign fuel, this quantity would be sufficient to run the whole fleet, war and mercantile, and to provide in the meantime the power for the inland industries so far as necessary.

In this connection it is a pleasure to say that the first industrial utilization of the by-products of gas manufacture by Diesel engines was made in this country by Col. E. D. Meier, Past-President of

Fig. 6 The World's Oil Fields

The American Society of Mechanical Engineers, who, in the year 1904, was the first to burn water gas tar of the gas works in Philadelphia in regular work for Diesel engines.

It will be seen from this that the influence of the Diesel engine on two other industries is increasing the manufacture of gas and coke, the by-products of which have become so important for power production that an enormous business is at present connected with them. It is especially noteworthy that every modern gas or coke works can be arranged to generate electric power by using its tar in Diesel engines. One fact which stands out clearly in this connection

is that coal, which seemed to be most threatened by the liquid fuels, will on the contrary gain a new and wider ground of application through the Diesel engine. As tar and tar oils are from three to five times more satisfactorily utilized in the Diesel engine than coal in the steam engine, a much better and more economical consumption of coal is obtained if, instead of being burned under boilers on grates in a wasteful way, it is first transformed into coke and tar by distillation. Coke is used in metallurgical and other general

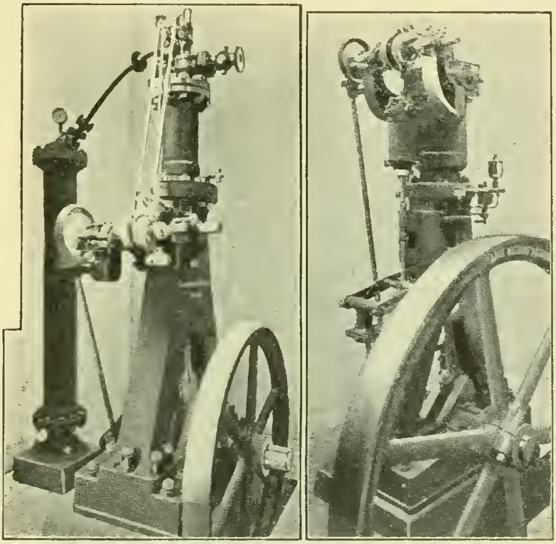


Fig. 7 First Two Diesel Engines built

heating purposes and from a part of the tar the valuable by-products are first extracted and undergo further processes in the chemical industry, while the tar oils and combustible by-products and a great part of the tar itself are burned in the Diesel engine under very favorable conditions.

It is evident that these circumstances are of differing importance in different countries, some of which are exclusively coal countries, others oil countries, and others again, like the United States, mixed coal and oil countries. It is difficult to predict what development will take place in a given country, but it is certain that the possibility of burning the by-product of gas works and coke ovens in the Diesel engine has resulted in Europe in making the different countries inde-

pendent as regards their supply of liquid fuel and has prevented increase in price of natural liquid fuel and the establishment of trusts or monopoly companies. This condition has been reached, not by laws or artificial means, but by the invincible force of scientific investigation and industrial progress before which the mightiest must bow.

The following statement may be made: The proper development of the utilization of fuel which has already been started and is now making rapid progress consists, on the one hand, of the use of liquid

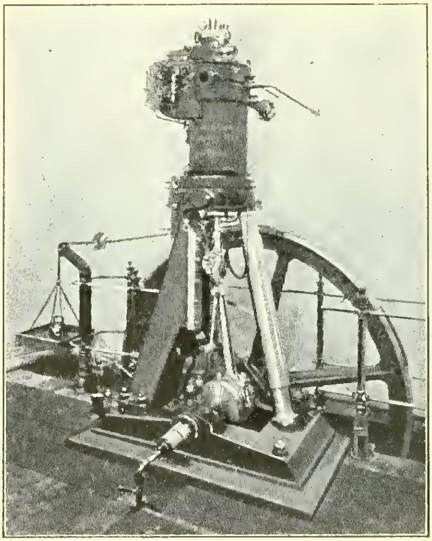


FIG. 8 THIRD DIESEL ENGINE BUILT. VIEW SHOWS TESTING BRAKE

fuel in Diesel engines, and, on the other, of gas fuel, also in the form of gasified coke, in the gas engines; solid fuel as little as possible for steam power generation, but as much as possible in the refined form of coke for all other heating and metallurgical purposes.

It is not generally known that it is possible also to burn vegetable and animal oils in the Diesel engine without difficulty. The first trials were made at the Paris Exhibition in 1900 with earth-nut oil, and I have since then repeated them with castor oil and palm oil, and also with animal oils such as brain oil. The use of vegetable oils may seem insignificant now, but may have in course of time an importance equal to that of some natural mineral oils and the tar

products at the present time. One can not tell what part these oils will play in the colonies of the future. In any case, it is certain that motor power can still be produced from the heat of the sun, which is always available for agricultural purposes, even when all our natural stores of solid and liquid fuels are exhausted.

HISTORY OF THE DIESEL ENGINE

I will now present an historical summary of the Diesel engine and will speak first of the four-stroke cycle engine. The first vertical stationary Diesel engine constructed in 1893 had the piston fitted

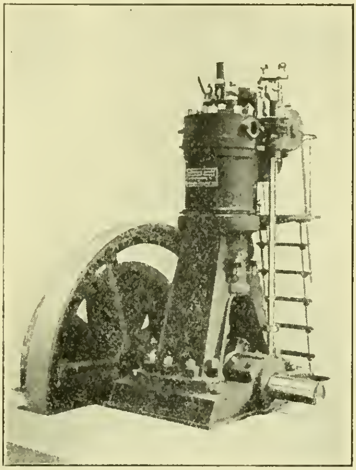


FIG. 9 DIESEL ENGINE BUILT IN 1901

with a piston rod and external crosshead, the cylinder having no water jacket. The camshaft was arranged very low and the valves were actuated by means of long rods. The starting storage chamber consisted of a wrought-iron pipe with riveted flanges and there was no air supply pump, the fuel being injected directly. I never succeeded in running this engine, not even one revolution. At the first injection of fuel—the engine being driven by outside power—there occurred a terrific explosion and the indicator went to pieces, nearly killing me. But I knew then just what I wanted to know: Pure air could be compressed to so high a point that the fuel injected into it would ignite and burn.

I then built my second engine. It had a base similar to that shown before, but a water-jacketed cylinder and the camshaft was placed

higher up. The most important difference was in the air supply pump for the injection of fuel, the necessity for which was only recognized after several years' experimenting and without which a smokeless combustion could not be effected.

The second engine also would not run and was always a source of danger. But it gave the first indicator cards of the whole cycle in the few revolutions I could get out of it. These first two engines taken together proved the practical possibility of carrying out the combustion process which I had developed theoretically years ago and which had been regarded impossible by the technical world. I myself would never have had the patience and the courage to continue the work after the disappointments of the first two years of experimenting, had I not been supported by an unalterable belief in the correctness of my mathematical deductions.

Fig. 8 shows the first reliable and complete Diesel engine finished in 1897 at Augsburg after about four years' laborious experimenting. It was a vertical engine of 18 h.p. having the piston connected to an external crosshead and worked on the four-stroke cycle. The illustration shows the engine with the testing brake attached, and with the other testing apparatus in the exact position in which it was used by the numerous commissions of engineers and experts who came from different countries to examine it. One of these experts was Col. E. D. Meier, who passed a few weeks in the engine room at Augsburg, testing and trying the little engine over and over again, and cross-examining the operating engineer, and thus forming his opinion about its significance. He was one of the first engineers to recognize its possibilities in the economical utilization of oil fuels through the practical realization of the Carnot cycle.

Mr. Adolphus Busch of St. Louis when on the point of sailing for home summoned Col. Meier to Paris, and after reading his report and discussing it from all points agreed in its conclusions and arranged a meeting with me at Cologne, at which we formulated and signed a contract giving Mr. Busch the control of my patents in the United States. Both gentlemen have since been the faithful pioneers of the engine in this country.

In the following year, 1898, a single-cylinder engine of 20 to 25 h.p. was built at the Augsburg works. It had all the characteristic details of the experimental engine just mentioned and was the first commercial machine. This type has remained up to the present the exclusive and almost stereotyped pattern for all stationary slow-speed Diesel engines built in the various countries.

The only alteration made in the year 1901 was the abandonment of the external crosshead and adoption of the trunk piston shown in Fig. 9. Vertical four-stroke cycle engines of from 10 to 250 h.p. per

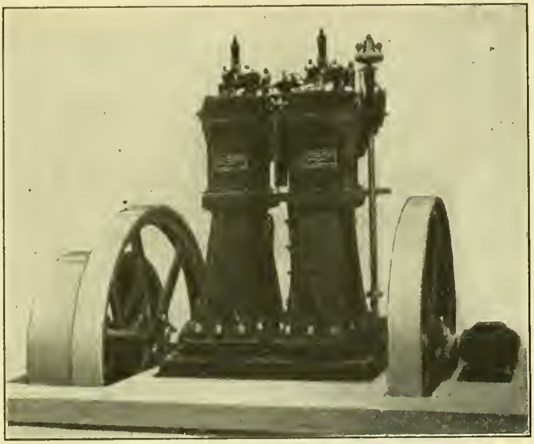


Fig. 10 250-H.P. Two-Cylinder Diesel Engine built in 1902

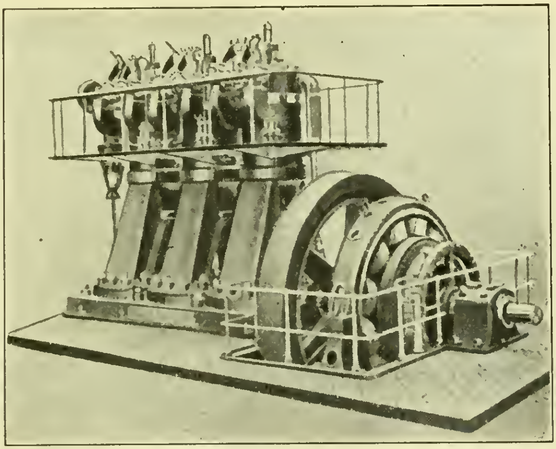


Fig. 11 500-H.P. Three-Cylinder Diesel Engine built by Carels, exhibited at Liege in 1905

cylinder were constructed after this pattern, and units up to 1000 h.p. were obtained by combining several cylinders. These engines ran at comparatively low speeds, from 160 to 200 revolutions, ac-

cording to their size, and were of very heavy construction. This type of engine was used exclusively as a stationary plant for various industrial purposes. Fig. 10 shows a two-cylinder engine of this type of 250 or 125 h.p. per cylinder built in 1902.

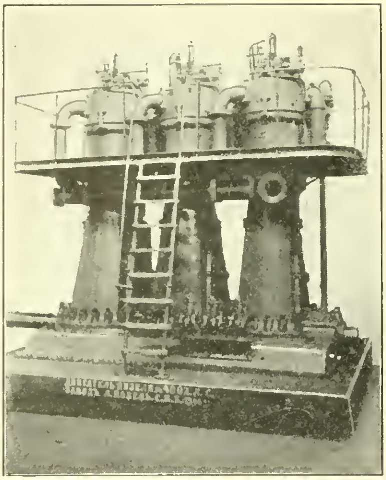


Fig. 12 400-H.P. Three-Cylinder Diesel Engine built in Russia

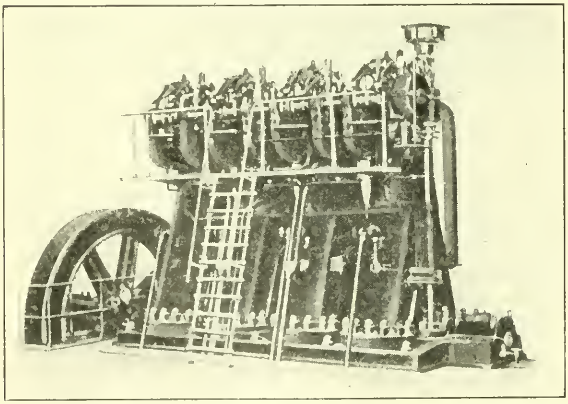


Fig. 13 600-H.P. Four-Cylinder Diesel Engine built by Tosi in 1911 and exhibited at Milan

Fig. 11 shows the well-known 500-h.p. three-cylinder engine exhibited by Carels at Liege in 1905. Fig. 12 shows a Russian 400-

h.p. three-cylinder engine, and Fig. 13 quite a new Italian four-cylinder engine of 600 h.p. built by Tosi in 1911 and exhibited in 1911 at Milan.

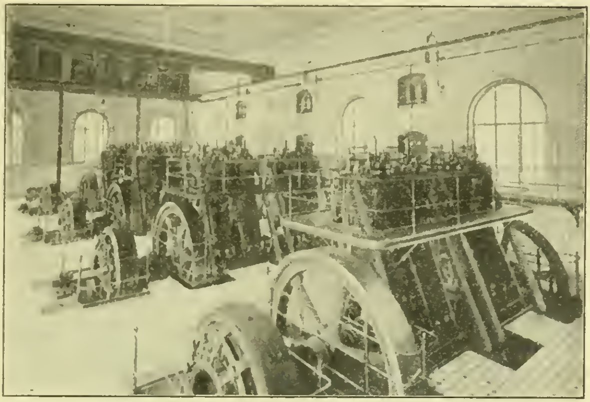


Fig. 14 1600-H.P. Diesel Engine Plant of the Russian town Kiev for the Electrical City Railway

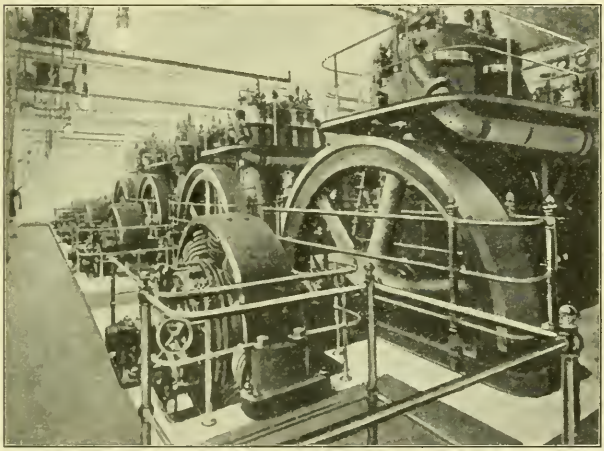


Fig. 15 800-H.P. Diesel Engine Plant in the Basement of the Tietz Department Store, Munich

MODERN EUROPEAN INSTALLATIONS

Figs. 14 and 15 show some large European installations. The first is a 1600-h.p. plant built for the electrical railway of the Russian

town of Kiev, and Fig. 15 an 800-h.p. plant in the basement of the Tietz department store at Munich. These two engine houses are typical of our European plants in the center of our big cities, electric stations and power plants in big stores, hotels, restaurants and the like. For it has been fully recognized that the Diesel engine is the predestined engine for big centers owing to the absence of steam boilers, smoke, and coal manipulation, the small space occu-

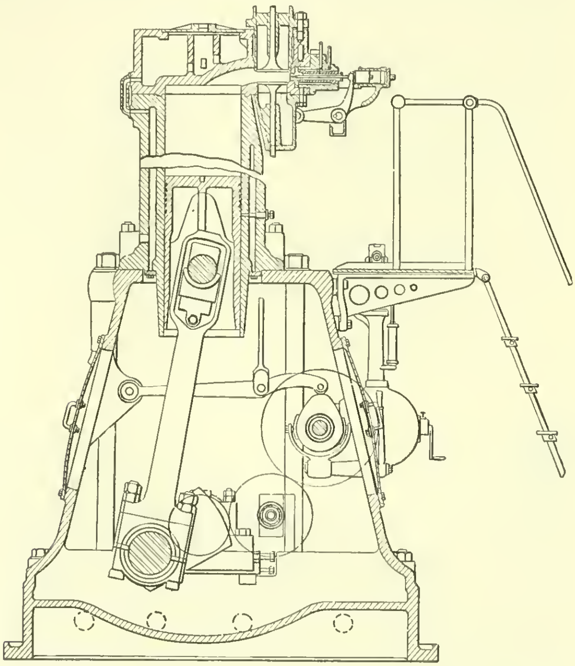


Fig. 16 Sectional Drawing of the American Diesel Engine

pied, cleanliness, and the complete freedom from danger. These engines are the only ones that can be installed in cities in any country without some special concession or permit.

This gives me an opportunity to speak of the wonderfully developed buildings or skyscrapers of America, the power plant of which, as far as I know, is generally a steam plant. I think that it would be a great improvement to serve these buildings mechanically by Diesel engines, the waste or exhaust heat of which would be sufficient to generate all the hot water necessary for use in the building. The steam heating alone would have to be done by boilers, which,

of course, would be fired by the same fuel as the Diesel engine and would be entirely stopped for the summer months of the year. Such installations would be not only simpler but also more economical in

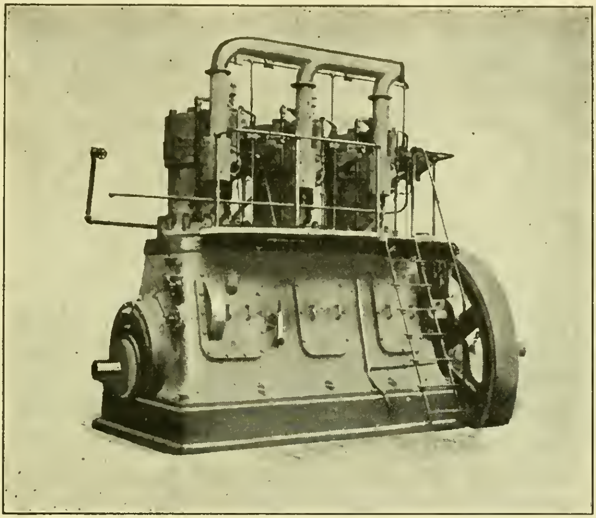


FIG. 17 OUTWARD APPEARANCE OF AMERICAN DIESEL ENGINE

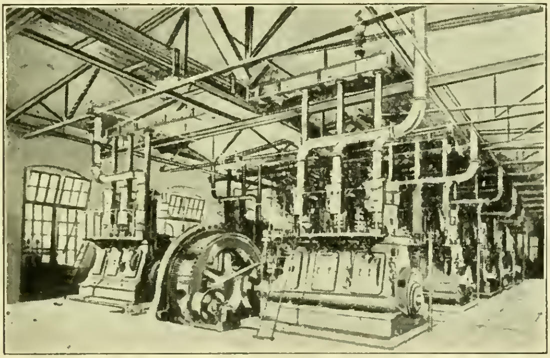


FIG. 18 VIEW OF DIESEL ENGINE PLANT, PRAIRIE PEBBLE PHOSPHATE COMPANY, MULBERRY, FLA., CONSISTING OF EIGHT DOUBLE UNITS OF 450 H.P. EACH

operating cost and would do away with the smoke problem in the large centers.

AMERICAN INSTALLATIONS

I have given several examples of this type of engine to show that those which have been built in various factories and countries are almost an exact copy of the old experimental engine which is today in the German Museum at Munich. Only in America has the design been simplified by the American Diesel Engine Company, succeeded by the Busch-Sulzer Brothers Diesel Engine Company, of St. Louis. In America these engines were built, from the beginning, without crossheads, an idea which, as already mentioned, was followed in the year 1901 by the European works after the American engines with trunk pistons had proved successful. They were also built from the beginning with a closed base frame, and this construction, as will be seen later, has also been adopted recently in the European high-speed engines. The American engines had no valves in the cylinder head, but they were placed in a chamber cast at the side of the cylinder head which necessitated the fuel needle being placed horizontally between the suction and the exhaust valves. Finally, the Americans, instead of driving the air pump for the injection of the fuel direct from the engine, always set it up independently and drove it either by a small extra engine, a transmission shaft, or an electric motor, in the manner in which air pumps are now set up in many Diesel engine plants on board foreign ships.

The accompanying illustrations, Figs. 18, 19 and 20, show some of the larger Diesel engine plants in this country. Fig. 18 is the plant of the Prairie Pebble Phosphate Company at Mulberry, Fla., so far the largest Diesel plant in America. This plant has 16 Diesel engines in 8 double units of 450 h.p. each and only 5 air compressors. Fig. 19 shows two 225-h.p. engines at the plant of the Pittsfield Electric Company, Pittsfield, Mass., and Fig. 20, three 225-h.p. engines at the United Gas Improvement Company's Works, Philadelphia, Pa.

The total aggregate of Diesel engines in the United States is now about 150,000 h.p. in about 300 plants.

As the central electric stations took up the Diesel engine very early, the necessity for quicker running engines arose. This need and the improvement in methods of construction and utilization of materials caused the gradual introduction of the new quicker running four-stroke cycle engines, with speeds of from 300 up to 600 revolutions. These, however, were still exclusively vertical. The main difference in construction as compared with the first type, was that the bearings of the crankshaft were connected with the cylinders by

means of light steel columns instead of by heavy cast-iron A-shaped frames, so that the cast-iron pedestal of the machine became a light crank case relieved from great strain; in addition, the thickness of all the castings was diminished. By this means the weight of the

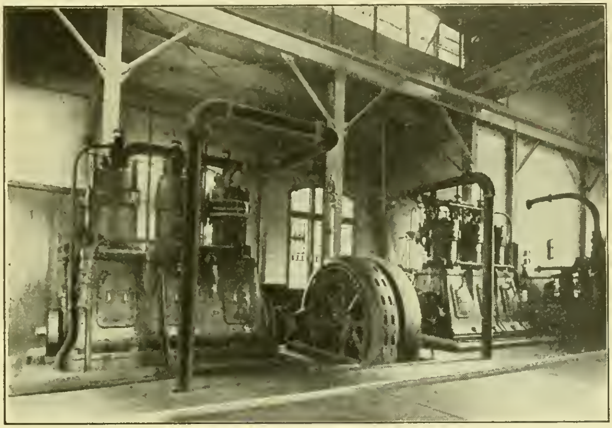


Fig. 19 View of Diesel Engine Plant, Pittsfield Electric Company, Pittsfield, Mass.

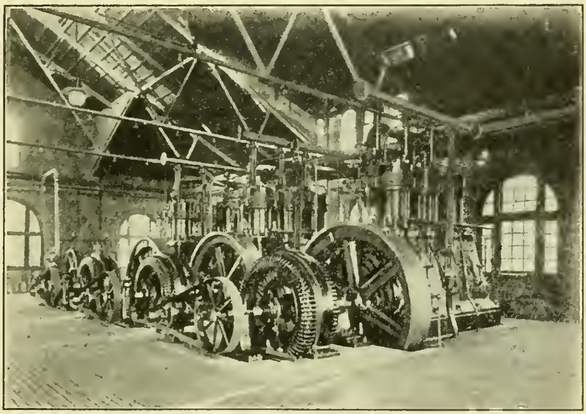


Fig. 20 View of Diesel Engine Plant, United Gas Improvement Company, Philadelphia, Pa.

engines was reduced to about one-fourth or one-fifth of the weight of the old types, or to about 50 kg. (110 lb.) per horsepower. Four-stroke engines of this kind are now built up to about 700 h.p. and are

especially suited to drive dynamos, blowers, and centrifugal pumps, and also as auxiliary engines on board large vessels, etc.

Fig. 21 shows a four-stroke cycle high-speed engine of this type made by Messrs. Sulzer Brothers in the year 1909. Fig. 22 shows a

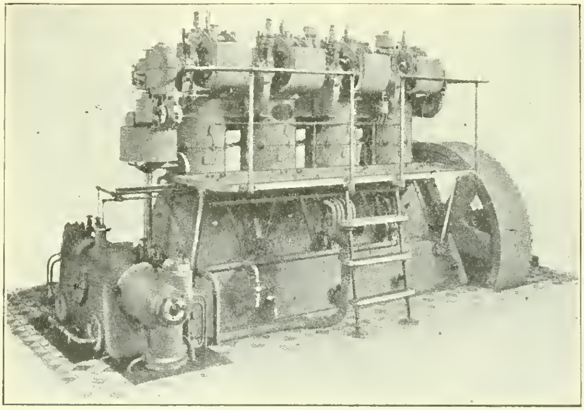


Fig. 21 High-Speed Four-Stroke Diesel Engine built by Sulzer Brothers in 1909

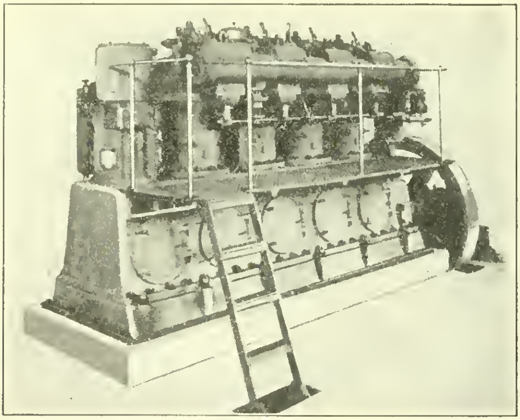


Fig. 22 High-Speed Four-Stroke 350-H.P. Diesel Engine built by Sulzer Brothers in 1911

four-stroke cycle high-speed engine of 350 h.p. made by Sulzer Brothers in 1911. This latter may be regarded as the final and permanent type of the vertical four-stroke cycle engine for stationary purposes, both for high and low speeds.

When in the last decade, through rapid development of the French submarines, an urgent need for a reliable submarine engine was felt, these four-stroke cycle engines were further reduced in weight by

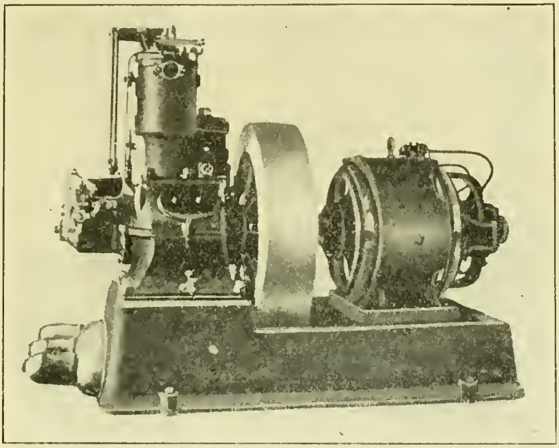


FIG. 23 5-H.P. ONE-CYLINDER DIESEL ENGINE, 600 B.H.P., BUILT IN 1909

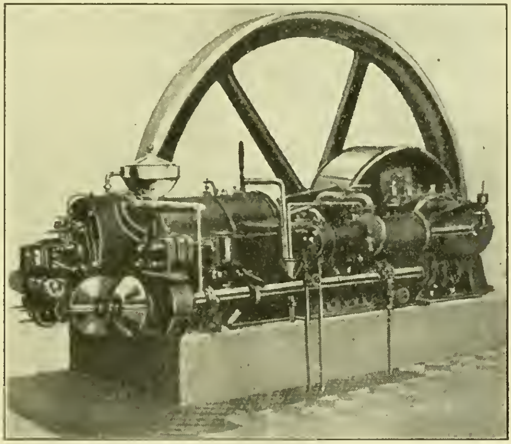


FIG. 24 HORIZONTAL KOERTING DIESEL ENGINE

using steel and brass castings, with still thinner walls, and they have also been fitted recently with reversing gears. I will return to this point later when discussing marine engines.

SMALL ENGINES

This summary of the development of the vertical four-stroke cycle engine would not be complete without a reference to the small engine which has recently been built. Fig. 23 shows a complete 5-h.p. one-cylinder plant, designed in 1909, for 600 r.p.m., driving a dynamo. For this construction, many hints have been taken from automobile engine designs.

HORIZONTAL STATIONARY ENGINES

After vertical engines had been used solely for about twelve years, horizontal four-stroke cycle engines were built. The first horizontal

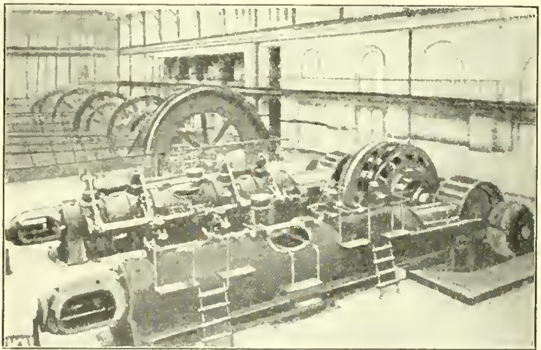


Fig. 25 Double-Acting Four-Stroke Twin Engine of 1800 to 2000 H.P., or 400 to 500 H.P. per Cylinder, 250 R.P.M., built by Maschinenfabrik Augsburg Nuremberg

engines were practically vertical engines laid on their sides without any independent structural innovations, as can be seen from Fig. 24, a horizontal Koerting engine in which all the valves are fitted in the cylinder cover in exactly the same way as in the old vertical engine. Gradually the designers freed themselves from the tradition of the vertical engine, and some details were so altered as to be more suitable for the horizontal position, and a type of engine was thus obtained which, in outward appearance, is strongly reminiscent of the horizontal gas engine. The Maschinenfabrik Augsburg Nuremberg built such horizontal Diesel engines for very high horsepower as double-acting four-stroke cycle engines with two or four cylinders arranged tandem. The largest engine of this kind is shown in Fig. 25; it is a double-acting four-stroke cycle tandem twin engine of 1600 to 2000 h.p., or 400 to 500 h.p. per cylinder, with a speed of 250 r.p.m.; this engine works entirely on water gas tar.

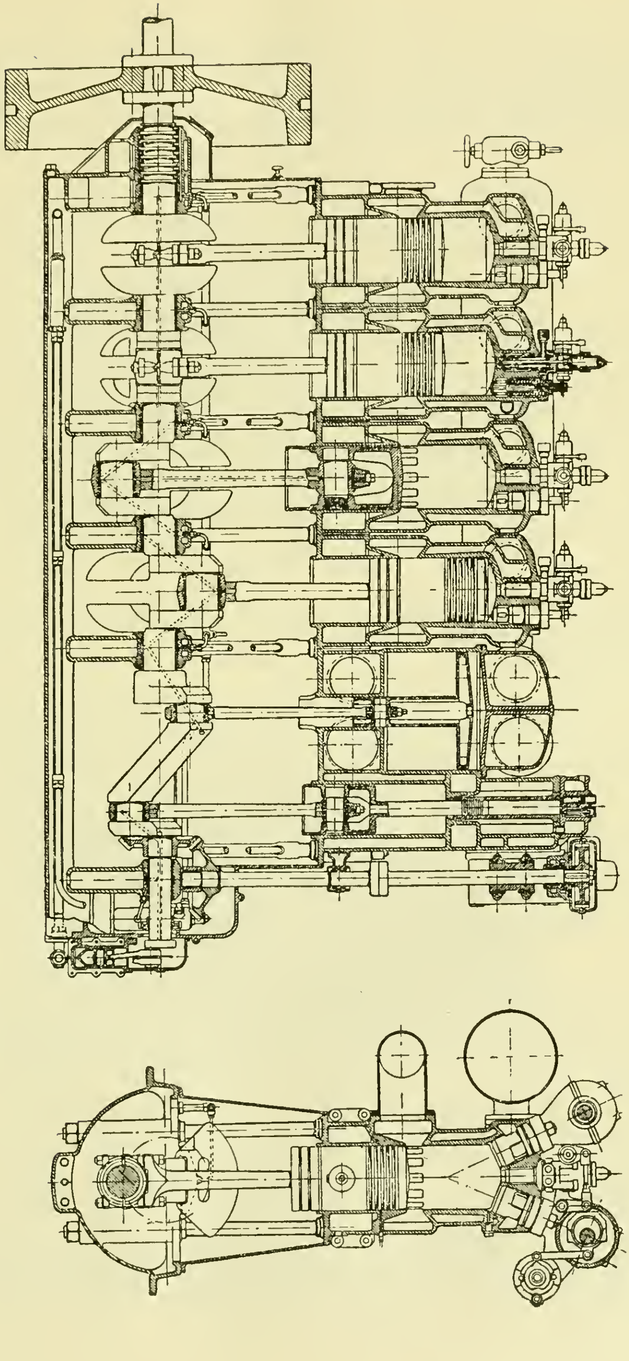


Fig. 26 Sectional Drawing of Sulzer Brothers' Two-Cycle Engine

TWO-STROKE CYCLE ENGINES

As I have often stated, the Diesel principle is essentially suitable in a two-stroke cycle engine, because the scavenging is not done with a fuel air mixture but with pure air, so that not only untimely ignitions are avoided, but fuel losses as well, and the scavenging can be done effectively and with almost any quantity of air desired. The two-stroke type is now almost on an equal footing with the old four-stroke cycle engine. This has been effected by working entirely on the original Diesel principle. I say "almost equal" because the four-stroke cycle engine still has better combustion and more economical fuel consumption, and is, above all, simpler in its method of working. It thus remains the standard perfect engine and still predominates for medium sized stationary plants up to 500 or 600 h.p. (no exact limit can be given), wherever the highest perfection and the greatest economy are desired. On the other hand, the two-stroke cycle engine with its smaller cylinders has now come into favor for stationary plants of higher horsepower, and, as a marine engine, seems to be the standard type. Two very different fundamental types of two-stroke cycle engines have so far been competing. The first is the engine made by Messrs. Sulzer Brothers, Winterthur, with separate scavenging pump, Fig. 26. The second, the Maschinenfabrik Augsburg Nuremberg engine, was brought out much later, and has a scavenging pump with an annular or stop piston placed underneath each combustion cylinder. Both engines are single-acting. Their relative merits can be settled only by experience.

A three-cylinder 750-h.p. Sulzer-Diesel two-stroke cycle engine and a still larger Sulzer-Diesel four-cylinder two-stroke cycle engine of the same system, of 2000 to 2400 h.p., are illustrated in Figs. 28 and 29. For the latter size two scavenging pumps are necessary.

MARINE ENGINES

The first marine Diesel engine of 20 h.p. was constructed in France in 1902 to 1903 for use on a canal boat, by the French engineers Adrien Bochet and Frederic Dyckhoff, in conjunction with myself. This engine had two pistons working in opposite directions in one cylinder, and worked on a four-stroke cycle. Others were also built in various sizes up to several hundred horse-power for some French submarines by Sautter, Harlé & Company, Paris.

This type of engine is of no practical interest today, but it has the historical interest at least of being the first Diesel engine used on a boat. Since the date named, the evolution of the Diesel marine

engine has steadily continued, chiefly because of the demand of the French submarines and Russian river boats. I have already mentioned that, later on, the high-speed four-stroke cycle engines, built for electric power stations, were made even lighter than before, and used for these same marine purposes. These engines were not orig-

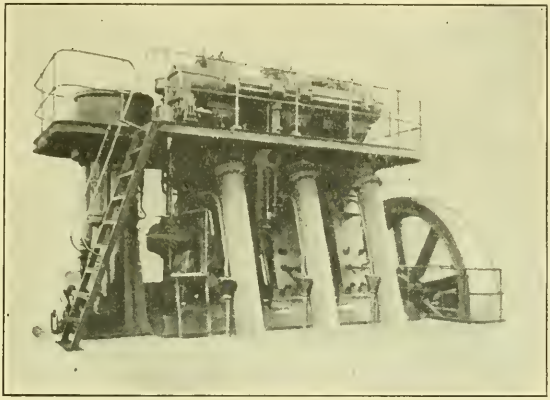


Fig. 28 750-H.P. Three-Cylinder Sulzer Brothers' Two-Cycle Engine (Stationary)

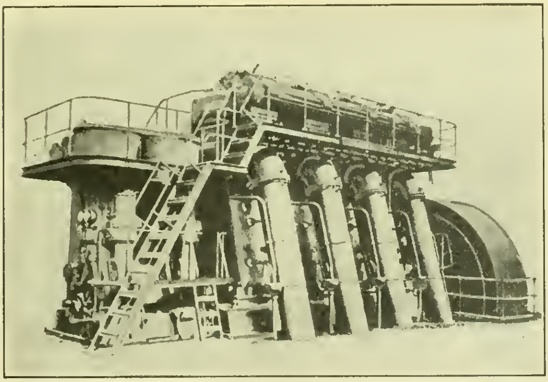


Fig. 29 2400-H.P. Four-Cylinder Sulzer Brothers' Two-Cycle Engine

inally reversible; on the contrary, they were used to generate electricity by means of which the propellers were driven indirectly for manoeuvering.

The first reversing marine two-stroke cycle Diesel engine, shown in Fig. 30, was built in 1905 by Messrs. Sulzer Brothers at Winter-

thur. At that time engineers were not quite clear as to the importance and value of the two-stroke cycle principle, and many firms went on trying for years to make the four-stroke cycle engine reversible. The first engine of this kind was built in the year 1908 by Messrs. Nobel Brothers at St. Petersburg, and was fitted to a Russian sub-

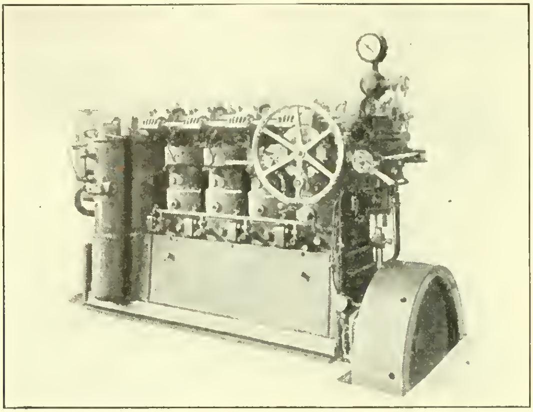


FIG. 30 FIRST REVERSING TWO-CYCLE DIESEL ENGINE, BUILT BY SULZER BROTHERS IN 1905

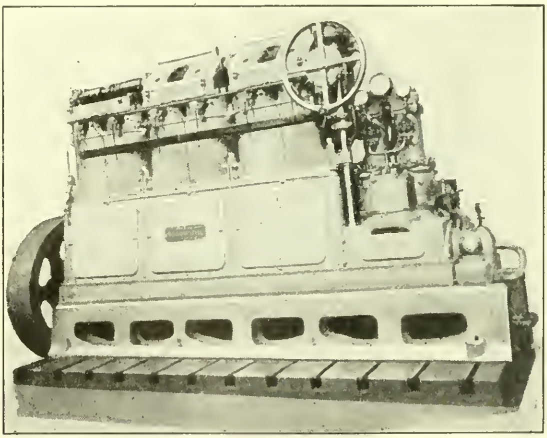


FIG. 31 120-H.P. THREE-CYLINDER REVERSIBLE MARINE ENGINE

marine. Fig. 31 shows this 120-h.p. three-cylinder engine. It is apparent even from the outside view what great mechanical com-

plications were at first caused by making the four-stroke engine reversible.

In many factories reversible four-stroke cycle marine engines are still built; but on the whole, engineers are inclined to abandon the four-stroke cycle engine entirely for navigation purposes, and to replace it by the two-stroke cycle engine.

The small four-cylinder engine of 30 h.p. and 600 r.p.m., illus-

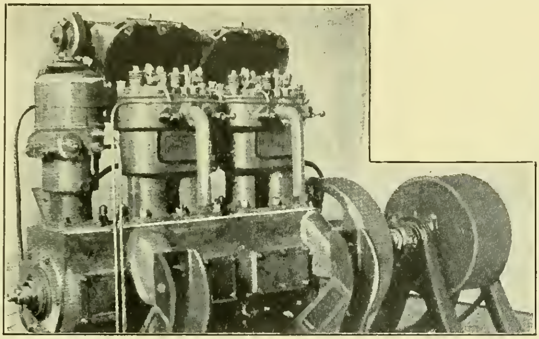


Fig. 32 30-H.P. Four-Cylinder 600-R.P.M. Four-Stroke Diesel Engine, built in 1909 experimentally as an Automobile Engine

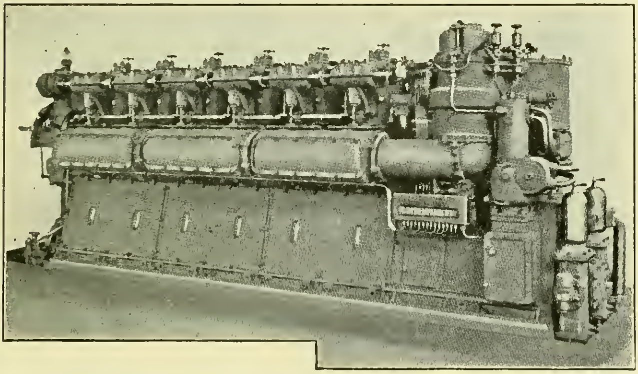
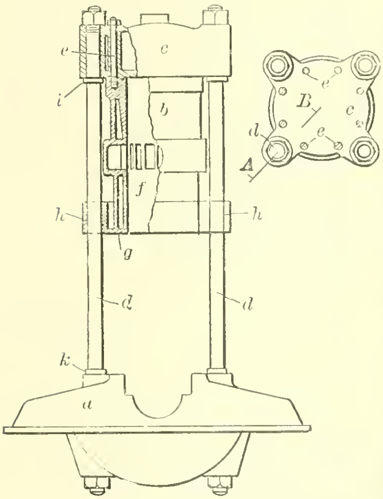


Fig. 33 Latest Two-Stroke Reversible Marine Engine built by Sulzer Brothers

trated in Fig. 32, is also a reversible four-stroke cycle engine. It was built for experimental purposes in 1909 as an automobile engine for heavy loads, but it can also easily work as a marine engine. The camshaft is mounted on the cylinder cover, and the illustration

shows the engine with the cover lifted. The view is of historical value in so far as it illustrates the first attempt to construct the Diesel engine as an automobile engine for traction wagons, and no doubt in future years these experiments will lead to satisfactory results.

Fig. 33 illustrates the latest two-stroke marine engine of Messrs. Sulzer Brothers which may be considered today as the standard type of a marine engine for smaller and medium sized powers.



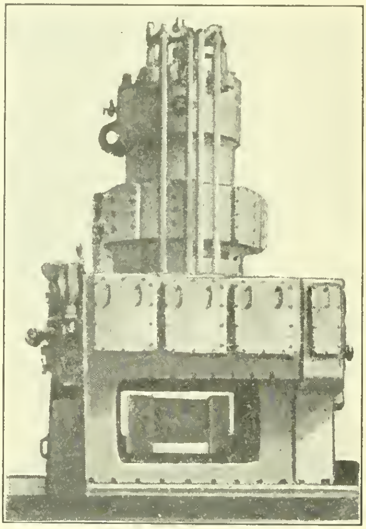


Fig. 34 Sectional Drawing showing Cylinder of 2000 H.P. (Design by Sulzer Brothers)

Fig. 35 Experimental Cylinder Unit of 1000 to 1200 H.P., built by Carels

For larger sizes of ship engines no standard type can be designated as yet. Each ship and each engine must be treated individually. Although several of the Diesel liners are still equipped with four-stroke engines, it is probable that the large ship engines will develop as a two-stroke type with crossheads and with exactly the number of revolutions required by the propeller. There is a tendency to make these engines to resemble steam engines as nearly as possible, even in those points where it would not be necessary, because the marine people adopt new types of apparatus more readily when they resemble apparatus that they are accustomed to.

It is generally known that very important experimental work

is being done in different places for the purpose of developing high power marine engines with cylinder units reaching 1000 to 2000 h.p. and more. Some manufacturers solve this problem with double-acting cylinders and others with single acting, but all on the two-stroke cycle. The Maschinenfabrik Augsburg Nuremberg is experimenting on a 6000-h.p. two-stroke double-acting engine with three cylinders of 2000 h.p. each. Messrs. Sulzer Brothers are just erecting a single cylinder of 2000 h.p., single-acting, Fig. 34, which permits an entirely free expansion of the cylinder under the action of the varying temperatures. Krupp's Germania yards have a 2000-h.p. double-acting cylinder on the testing stand. Vickers Sons and Maxim are experimenting on a large scale with the double-acting two-stroke cycle type. These large cylinder units are kept secret as long as the experimental work is going on, so that views of them can not be shown, but Fig. 35 shows a cylinder unit of 1000 to 1200 h.p., built by Messrs. Carels, which is yet in the experimental stage like all others of these large cylinders.

If, as seems probable, these tests give satisfactory results, the era of very large Diesel engines has begun. From motives of prudence, the various navies which are now fitting some warships with Diesel engines, started with one Diesel only out of the two or three engines on board; the Diesel works alone when the ship is cruising, but for high speed, steam is used as an auxiliary. It is evident that large warships will not be fitted solely with Diesel engines until practical tests on the high seas have proved to be completely successful.

DIESEL SHIPS

I believe it will be of interest to give a complete list of Diesel propelled ships, but as this would be too long, I will simply give a summary of Diesel engine vessels completed or in course of construction. The total aggregate of these vessels is 365, and an analysis shows the following approximate distribution:

Oil tank vessels	30
Tugs	40
Motor sailing vessels	10
Merchant vessels, freight, passenger and combined	50–60
Fishing boats	15
Submarines (among them 17 U. S. Navy submarines)	140
Smaller warships, small cruisers, gunboats, mine-laying boats, and the like.	40
Small marine craft	20
Miscellaneous	20

A brief historical review of Diesel ships with results of trials and journeys, as far as a record of them has been obtainable, follows:

The *Venoge* is one of the very first small cargo boats plying on Lake Geneva, with non-reversing engines driving the propeller elec-

FIG. 36 PASSENGER DIESEL SHIP *Uto*

FIG. 37 GERMAN TUG *Fortschritt*

trically. The captain manoeuvers the ship from his bridge only by electrical contacts, the motor running below him without any engineman. This boat exhibits the characteristic features of the Diesel ship, namely, the motor is as far back as possible, the absence of a funnel, the deck quite clear and the whole body free for cargo.

Fig. 36 is a view of the *Uto*, a passenger vessel on Lake Zurich of 200 tons displacement, 250 to 260 h.p., and has made regular passenger trips on Lake Zurich since the summer of 1909. It is a converted steamer, the weight of the previous steam plant, including coal and water, having been 14,700 kg. (14.16 tons) for 120 km. (64.6 sea miles) radius. The weight of the new plant for the double power and 1200 km. (646 sea miles) radius is (10-fold) 9750 kg. (9.6 tons). The cost of fuel is one-fourth of the previous cost, and the saving in labor is one man. The cost of fuel per km. is 10.5 cents (1.6 d.) per mile.

Fig. 37 shows the German tug *Fortschritt*, of 150 h.p., in Hamburg harbor. It has also made very stormy voyages on the open sea and carried fuel for eight days. The gain in length is one-third

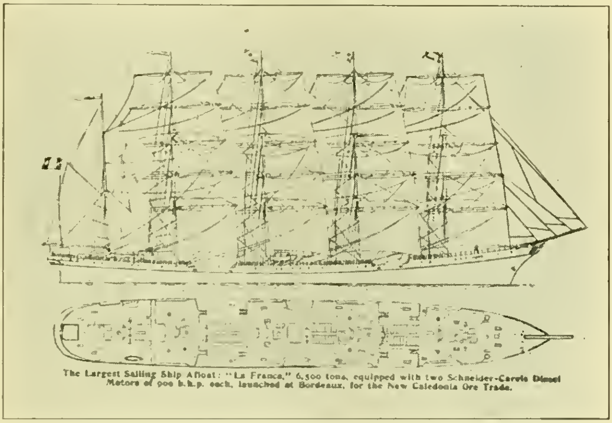


FIG. 38 SECTIONAL VIEW OF MOTOR SAILING VESSEL *La France*

over a steamer; gain in weight of machinery, about one-fourth over a steam plant; weight of fuel, only 20 to 25 per cent of weight of coal for the same power in a steamer.

The Russian tug *Jakut* has a towing capacity of 4000 tons. The engines are 320 h.p. and have worked satisfactorily for two years. The manoeuvering power is better than with steam engines. The *Jakut* and a steam ice breaker went to the assistance of a ship and towed her out of the ice, on which occasion the fuel consumption of the *Jakut* was 4380 kg. (9654 lb. or 4.3 tons) as compared with 32,500 kg. (71,630 lb. or 32 tons) by the steamer.

The *San Antonio* is the first sailing boat with a Diesel motor of

200 h.p. It navigated between the Baltic and the Mediterranean and proved so satisfactory that quite a new type of ship, the auxiliary motor sailor, is now being developed on a very large scale.

The *Quevilly* is another motor sailor of about 6500 tons displacement and 600 to 700 h.p. on two propellers. The propellers can be

Fig. 39 Polar Ship *Fram*

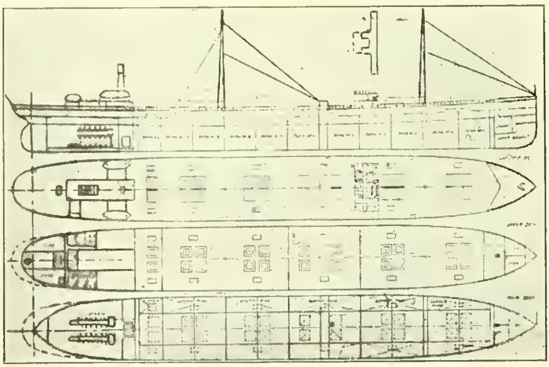


Fig. 40 Oil Tank Vessel building by Krupp

uncoupled when using only the sails, and their resistance when running light causes a loss of one-half a knot in speed. It was the first ship with Diesel engines to cross the Atlantic, sailing from Rouen to New York and back in March 1911, the engines working during 1200 hours. She made a sensation entering New York

harbor under her own power and without the help of a tug. The second voyage was made in July and August 1911, and the cost of fuel was $1 per hour per engine, a very satisfactory result. The third voyage was between Havre and New York and lasted 38 days, during 26 (650 hours) of which the engines worked against a strong wind. The vessel takes its fuel in New York for the double journey at a price of $7.50 to $8 per ton. After the very good experience of this ship the owners are now building another motor sailor.

Fig. 38 is a view of *La France*, the largest sailing vessel in the

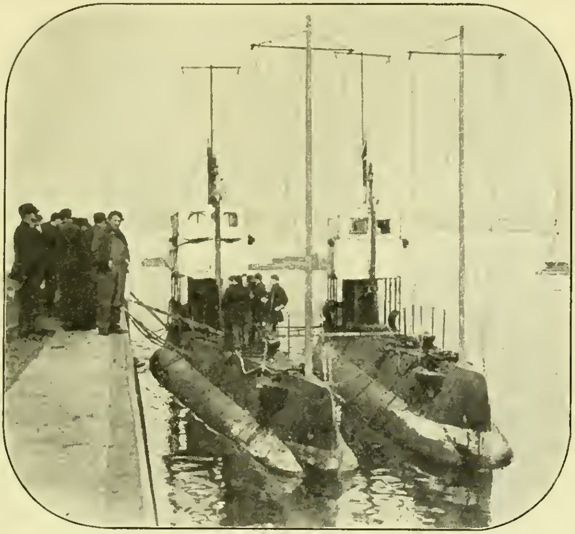


FIG. 41 FIRST TWO UNITED STATES SUBMARINES, E1 AND E2

world. It has five masts, 10,730 tons displacement, length 131 m., 1800 to 2000 h.p. in two engines, and sail area 69,966 sq. ft. It runs between France and New Caledonia for the Caledonia ore trade and was launched on November 16, 1911.

Fig. 39 shows a small but most interesting motor sailor, the old north polar ship *Fram*, fitted with Diesel engines. The gain through replacing the steam engine by the Diesel engine is: in engine space, 45 per cent; in weight of engine, 60 per cent; in weight of fuel, 80 per cent; in space for fuel, 85 per cent; several years' supply of fuel can be stored. Of 380 tons cargo capacity, 100 tons were previously required for the coal storage. The *Fram* sailed for six months from Christiania to the south polar regions without touching land and

without reporting. During the voyage to the Antarctic, the engine worked for 2800 hours without giving trouble. On March 13, 1912, Captain Amundsen, on his return from the South Pole, wired only these few words, "Diesel motor excellent."

The Russian oil tank vessel, *Djelo*, 5700 tons displacement, 1000 to 1200 h.p., made several stormy voyages on the Caspian Sea in the year 1911. It embodies the special features of the Diesel ships: a clear deck from one end to the other, no funnels, only two small exhaust pipes on the stern with invisible exhaust; engines on the rear end of the ship, with ship body free for cargo.

There are a great many oil tank vessels under construction, the largest one, Fig. 40, being built by Krupp in Germany for the German Standard Oil Company, with a carrying capacity of 15,000 tons of oil and length 160 m.

The latest passenger and freight boat, the *Borodino*, with two engines of 1200 h.p. each, built by Nobel Brothers, made her tests toward the end of 1911. There are six of these boats in commission and a ship of the same kind is building at the present time at Cockerill's in Belgium for use on the Congo River on order of the King of Belgium. This will be the first Diesel ship on colonial rivers.

Today the navies of the world have adopted almost exclusively the Diesel engine as the motive power for submarines, after the pioneer work in that direction had been done in my offices in Munich in connection with several engineers of the French navy.

The submersible boat *Hvalen* for the Swedish navy was constructed by the Fiat Company of Spezia, Italy. This is quite a modern boat of 185 tons displacement, and is propelled by three sets of Diesel engines. She left Spezia on July 30, 1911, and arrived at Cartagena, Spain, August 2, 1911, having covered a distance of 790 nautical miles without stopping. She then went to Portsmouth, thence to Kiel and Stockholm. The complete voyage of 4000 miles was accomplished without escort and without mishap. She met with extremely rough weather, but behaved very satisfactorily and won high praise from her captain, Magnussen.

Fig. 41 shows the two first United States submarines, E–1 and E–2, fitted with Diesel engines.

The new Russian gunboat *Kars*, of 1000 h.p. on two propellers, six cylinders, four-stroke, was tested in 1911: The consumption of fuel with full load in 100 hours was 1200 lb. against 4500 to 5000 lb. with coal.

In the case of torpedo boat destroyers equipped with Diesel en-

gines and with steam power, it is of particular importance that in the Diesel ship the engines are entirely under the armored deck, while in the steamship the steam engines and boilers must reach up nearly to the upper deck, and furthermore the deck is surmounted by the smoke stacks. The upper deck of the Diesel ship is perfectly free, permitting a much stronger gun equipment. The space for the Diesel engines is one-half that for the steam engines and boilers, which increases considerably the space for the officers and the crew.

Mr. Davison in England has calculated the effect of replacing the steam engine by a Diesel engine on the Destroyer *Paul Jones* of 400 tons displacement, 8000 i.h.p. engines, as follows:

	Steam	Oil
Weight of engines	449,000 lb.	317,000 lb.
Weight per b.h.p	64 lb.	44 lb.
Radius of action at 10 knots and 180 tons fuel	1,700 knots	10,000 knots
Radius of action at 28 knots and 180 tons fuel	630 knots	2,950 knots
Fuel per b.h.p-hr. at 20 knots	2.34 lb.	0.5 lb.
Engineers and stokers	54	21
Fuel consumption in 1 year (20,000 marine miles)	2,100	360
Cost of fuel	3,840	924
Cost of engine crew labor	4,500	1,920
Cost of repairs	2,000	400

A comparison of the equipment of steam and Diesel engines for battleships made by English Navy engineers is as follows: Steamship, 4 guns of 30.5 cm., the motor ship, 10 guns of same size. In the latter case, due to the absence of funnels, each of these ten guns can be directed to nearly every point of the horizon; for instance, all ten can be directed towards one side, giving more than double the fighting capacity of the steamship. Also the smaller guns are considerably different; the steamship has only 12 smaller guns of 15 cm., the motor ship has 18 guns of 10 cm.

PASSENGER, FREIGHT AND COMBINED FREIGHT AND PASSENGER VESSELS

Fig. 42 shows a small merchant vessel, *Rapp*, cruising in the Swedish waters. The cargo capacity is 300 tons, 120 h. p. The engine runs for long periods at 55 to 60 revolutions, although the normal speed is 300 revolutions. Since 1908 the vessel has made numerous voyages between points in Sweden, Finland, Germany, Holland, England, Iceland and Norway. On a voyage from the east to the west coast of Sweden, through the canals, 75 locks had to be passed through and the manoeuvering power proved to be very satisfactory.

Fig. 43 shows the *Toiler*, the first Diesel sea-going vessel, with a cargo capacity of about 3000 tons, 360 h.p. The steering is controlled by compressed air. The cabins are warmed by water heated by the exhaust from the engines. The first voyage from the Tyne to Calais with a cargo of coal was made in very bad weather in the summer of

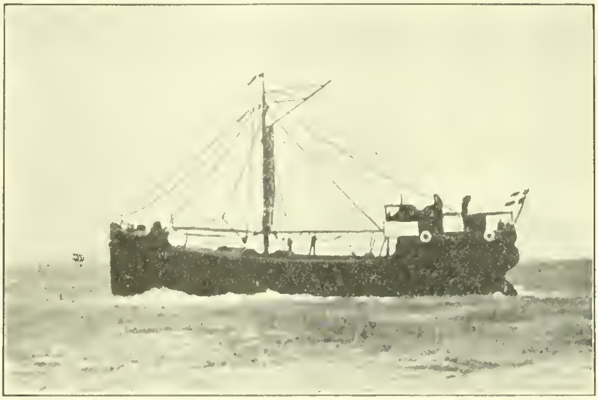


Fig. 42 Swedish Merchant Vessel *Rapp*

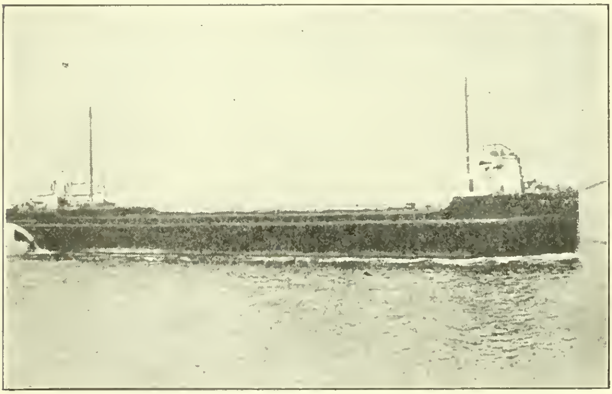


Fig. 43 Passenger and Freight Vessel *Toiler*

1911. The oil consumption was 1.65 to 1.75 tons in 24 hours. A steamer of the same size would consume 8 to 9 tons of coal per day, 6 times more. The saving in cost of fuel as compared with a steamer shows 50 per cent gain in cargo capacity, 60 tons. In a voyage to North America in September 1911, the fuel consumption was 2

tons per day. The saving in cost of fuel as compared with a steam plant was $11; the saving in labor cost $5 per day. The manoeuvering power proved to be very satisfactory.

Fig. 44 shows *Romagna*, of 1000 tons displacement, 800 h.p., put in commission September 1910, making regular voyages on the Adriatic Sea between Ravenna, Trieste and Fiume in the Summer of 1911. In consequence of the faulty loading of the cargo, this beautiful vessel sank in a terrible sirocco in November 1911.

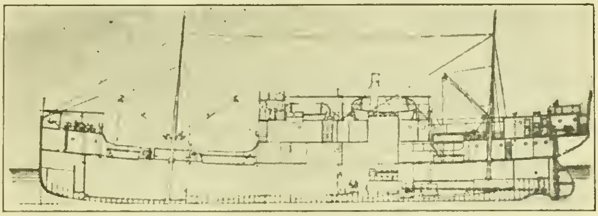


Fig. 44 Longitudinal Section of *Romagna*

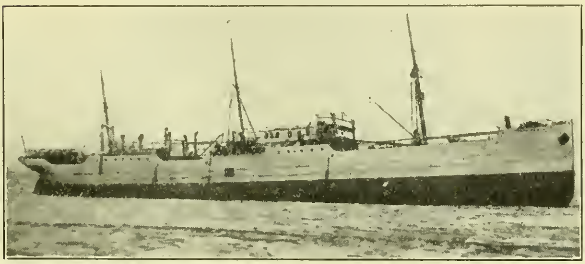


Fig. 45 Diesel Liner *Selandia*

A Diesel engine Hamburg-American liner of 5600 tons is under construction at the Aktien-Gesellschaft, Weser, of Bremen. She will have two Diesel motors of about 2000 i.h.p. and will be delivered to her owners about the middle of this year.

Fig. 46 shows in a peculiarly striking, although in a somewhat popular form, the advantages of the Diesel plant in the freight and passenger ship *Jutlandia*, which is now being completed by Messrs. Barclay, Curle & Company and will run between Europe and Siam. It is a peculiar coincidence that 100 years separate two such events as the introduction of the marine steam engine on the River Clyde

and the launching at Glasgow of the first Diesel liner built in the United Kingdom. The ship is of 5000 tons displacement and will have engines of 3000 h.p. The fuel is carried in the vessel's double bottom. The accommodation for her passengers will be excellent. She will have magnificent staterooms, each fitted with its own bathroom, and a large dining saloon, smoking and music rooms. This luxurious accommodation is possible because of the space saved by the Diesel engine. This ship has no dangerous steam mains, the dreaded and dirty operation of coaling is absent, and while the passengers appreciate the absence of heat from the boilers and smoke from the funnels, the owner will remember that the fireman's quarters, the

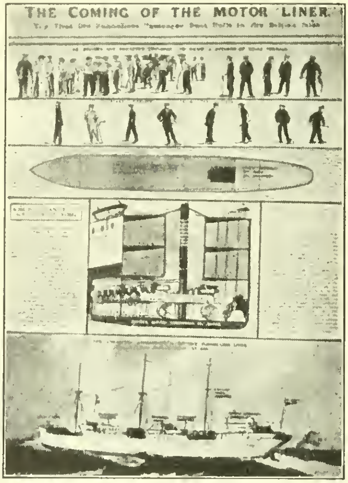


FIG. 46 COMPARATIVE ILLUSTRATION OF ADVANTAGES IN MOTOR LINER, *Jutlandia*

boiler and bunker space, and the room occupied by numerous ventilation shafts and the funnel uptakes can be utilized for carrying more passengers and freight, the gain in the *Jutlandia* being more than 20 per cent. The exhaust from the engines will be carried up the hollow steel mizzen-mast so that no fumes reach the passengers.

The uppermost portion of this view shows how in place of 25 engineers and stokers in a similar steam-driven vessel, only 8 engineers will be required to operate the new Diesel vessel. The third section shows how small a space is occupied by the new Diesel engines as compared with those of a steamer. The center view shows the arrangement of the Diesel engines and the method of getting rid of

the exhaust. The lower view shows the curious headless appearance of the new ship when at sea.

Fig. 45 shows the *Selandia* of the East Asiatic Company, Copen-

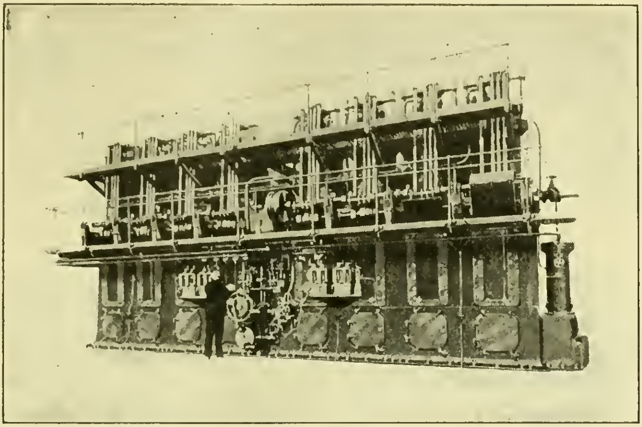


Fig. 47 View of Engine on Board *Selandia*

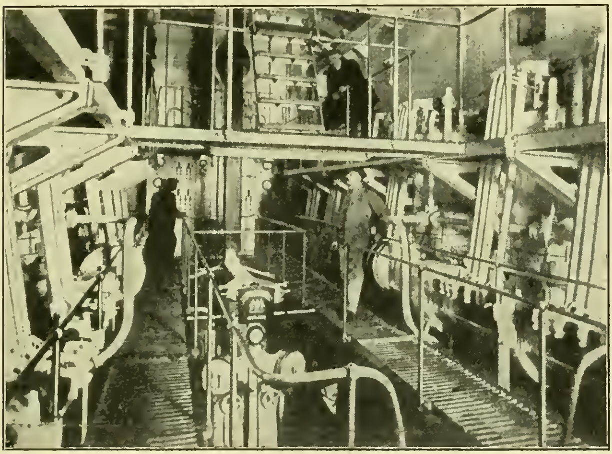


Fig. 48 View of Engine Room on Board *Selandia*

hagen. This ship was in the docks of London about eight weeks ago after having been given severe trials in January in the presence of British, French, German, Italian and Russian engineers. The displacement is about 10,000 tons, length 386 ft., two main Diesel

engines aggregating 2500 h.p., two auxiliary engines aggregating 250 h.p. for the transmission of electric power to operate the winches and windlasses.

Figs. 47 and 48 give different views of the engines and the engine room. The ship has now made her first trip to Bangkok successfully. The cargo is 1000 tons more than in a steamship of similar size. The owners anticipate a saving in the fuel bill of $25,000 per annum and a gain in the yearly freight receipts of about $15,000. The East Asiatic Company has just now placed orders for 11 Diesel ocean liners of the same type and of tonnage ranging from 6000 to 10,000 tons.

LOCOMOTIVE ENGINES

Of the Diesel locomotive nothing has heretofore been published. From the early days of my invention I have been of the opinion that the special features of the Diesel engine would be of even greater importance for transport purposes than for stationary work and for that reason I have devoted much time to the development of the engine as motive power for transportation mediums. I have already mentioned that I made the first small ship engine in 1902 and that since that time the Diesel marine engine has been developed without interruption. I further mentioned that I made the first automobile engine for trucks in the year 1899, and that I looked forward to the development of this branch within a few years. Finally, I have to say that I have worked for five years, together with Sulzer Brothers, at Winterthur, and Mr. Adolph Klose of Berlin, on the construction of a Diesel locomotive, and that the first express train locomotive of 1000 to 1200 h.p. was finished a few weeks ago, and is now on the testing bed in the Winterthur shops. Five years is a very long time, and to explain why the work has taken so long, I must mention that the thermo locomotive is the most difficult problem of construction that can be taken up in the way of modern engine building, not only on account of the difficulties in starting and manoeuvering with this special kind of motor, but also on account of the limitation in space and weight. Compared with this, the development of the reversing and of the Diesel ship engine has been relatively simple. Fig. 49 shows the design of this locomotive, the car of which was made in the locomotive works of A. Borsig at Berlin. It is 16.6 m. long over the buffers and has two buggies of two axles each (1–1), and two driving wheels (2–2). The latter are not directly coupled with the engine but indirectly with the

blind axle (3) which is in the meantime the crankshaft of the Diesel engine (4).

The Diesel engine is an ordinary two-stroke cycle engine with four cylinders (4—4) coupled in pairs under an angle of 90 deg., and which drives the blind axle (3), cranks of which form an angle of 180 deg. This disposition gives complete balancing of the moving masses, the first and most important condition when putting such engines on a movable platform. Between the working cylinders are placed two scavenging pumps (5) driven by levers from the connecting rod. Beyond the engine in the roof of the car is placed the muffler (6). On the right of the main engine stands an auxiliary engine (7). This latter consists of two vertical two-stroke cycle cylinders (7–7) coupled to horizontal air pumps (8–8) driven by these cylinders. The cooler for the air compressed by these pumps is indicated at (9). These air pumps serve, according to a special and patented process, to increase the power of the main engine when starting, manoeuvering and going uphill, in such a way that auxiliary compressed air and auxiliary oil fuel are conducted into the main cylinders, by which means the diagram is enlarged, making the engine as elastic as a steam engine. For the current running of the locomotive the main cylinders work like ordinary Diesel engines without the help of the auxiliary. To the right of the main engine is placed a battery of air cylinders (10), which help the action of the auxiliary engine and which can be refilled by the auxiliary engine at times when the latter is not used. Two pumps (11 and 12) provide for the water circulation in the cylinder jackets. Apparatus for the back cooling of the water by evaporation is indicated at (13), and at (14) the tanks for fresh water and for fuel. A small donkey boiler at (15) is for the heating of the train. The channels (16) under the roof lead the fresh air to the suction pipe of the different motor and pump cylinders. The whole plant is contained in a closed engine room, which makes the locomotive look from the exterior like a modern steel car.

The engineer can operate equally well on either end of the locomotive, as the engine is arranged for running in both directions. He has a direct view of the track. Both doors and platform lead from the engine to the train.

The total weight of the locomotive in service is 85 tons. Fig. 50 gives the details of the car construction.

I cannot predict whether this attempt at an entire revolution in the working of railways will be successful at the first attempt, or whether it must be repeated, but one thing is certain to me, the

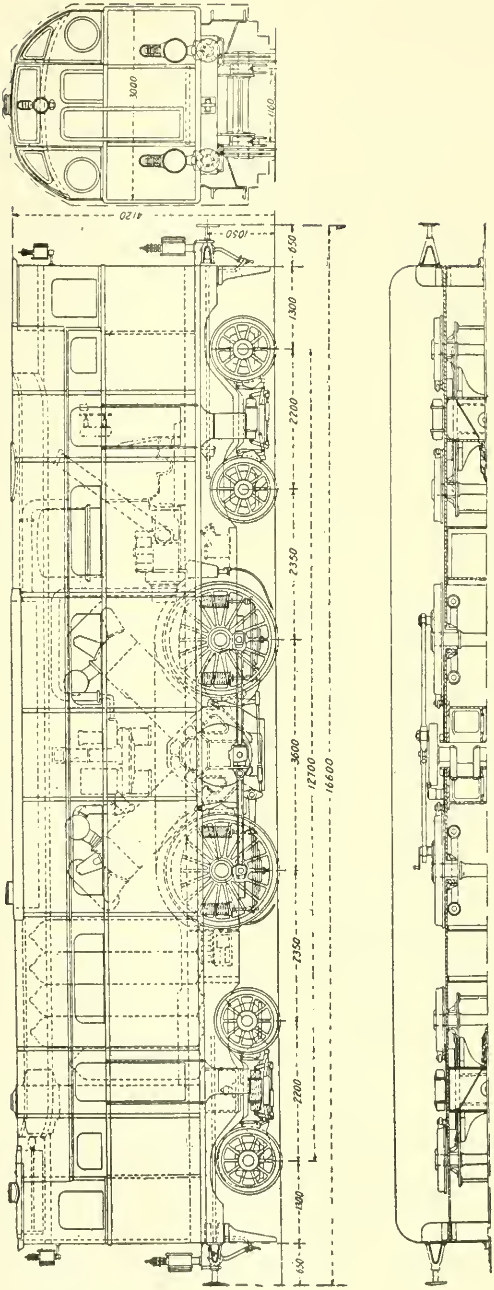


Fig. 49 Sectional Views of Diesel Locomotive

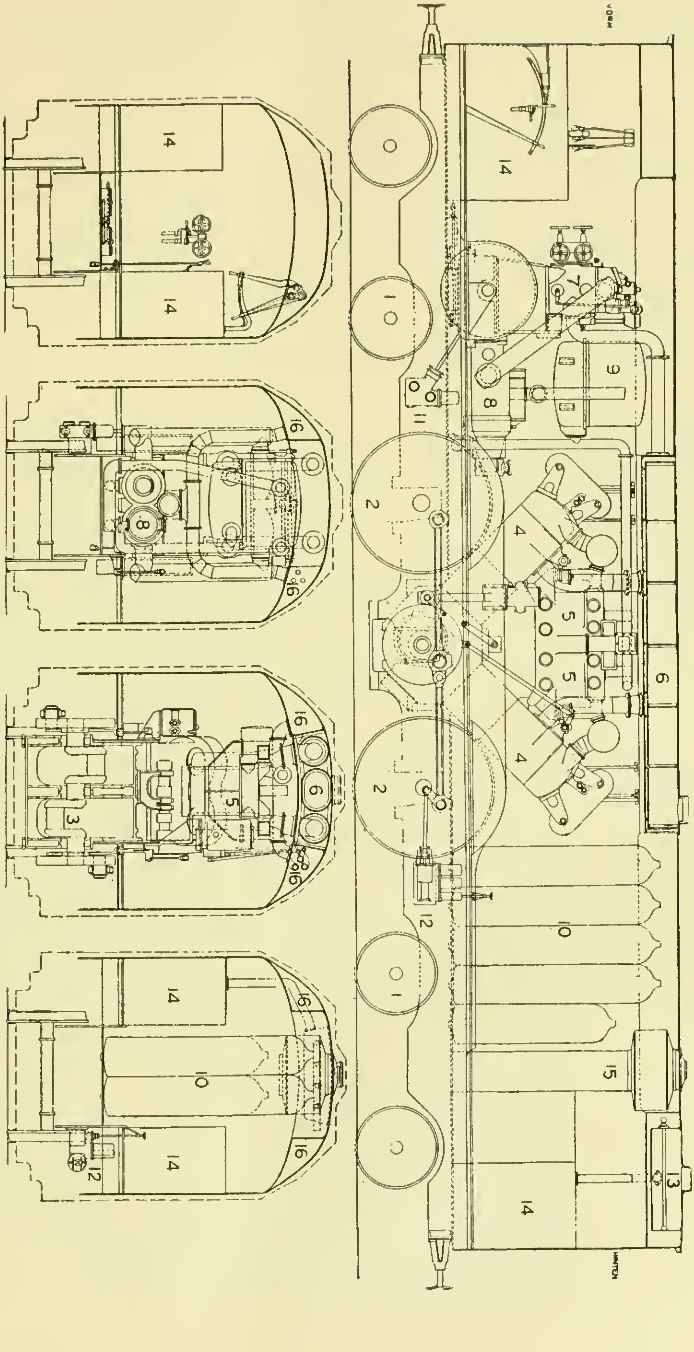


FIG. 50 SECTIONAL VIEW OF DIESEL LOCOMOTIVE SHOWING CAR CONSTRUCTION

Diesel locomotive will come, sooner or later, according to the perseverance with which the problem is followed.

CONCLUSION

Before concluding my lecture I should like to touch upon an important question which has been put to me by the Secretary of the United States Navy, to whom I paid my first visit upon arrival in this country, and which has been repeated to me nearly every day since I left the pier at Hoboken: Why is America so far behind Europe in the development of this new prime mover, which in fact is no longer new?

To answer this I must emphatically state that the Diesel engines built in this country, after having passed the necessary manufacturing apprenticeship more than ten years ago, have been and are quite as good as our European machines. So the question is not a technical one, but merely a commercial one, or, even more, one of the general economic conditions in this country. I do not know the United States sufficiently to judge these conditions on my own behalf, but I have tried to find out in my conversation with many prominent engineers, and the following is what I could learn:

a Coal is much cheaper than in Europe, and therefore people are more wasteful with it. While the leading idea in Europe is always economy in operating cost, the leading idea in America is economy in first cost. The word efficiency, which is the base of every contract with us, seems to be unknown to a vast proportion in this country; of course, not to engineers, but to business men and to buyers of engines.

b In the same order of ideas, American steam engines are much cheaper than ours. But the Diesel engine is not and will not be a cheap engine; it aims to be the best engine and must be constructed of the highest class of materials with the most skilled workmanship. This makes it difficult for it to compete with this type of engine under the ideas which prevail. The people here are accustomed to engines of very low price, taken per pound, and the price of Diesel engines per pound seems to them exorbitant; several people have said that they would never buy an engine at that high price per pound, even with a guarantee that the whole plant would earn its cost by the savings of a few years only.

c The lack of capital on the part of the prospective purchaser in many cases, and also in many cases the higher rate of capital interest prevailing in the American money markets.

d In the last few decades the general business profits have been so large that people did not care for the most economical methods of production and for the strictest economy in the fuel bill as well as other expenses, the ruling object having been to manufacture quickly and in quantities without regard to the cost. America has not had to compete with the industrial countries of the world, as Europe has.

I have been told by American engineers that what has happened to the Diesel engine has also happened to the large gas engine, especially with blast furnace gases, and also with the steam turbine, both of which were taken up in this country long after their development in Europe.

The same has happened also with the by-products of coke ovens. Even today, the wasteful bee-hive oven is in use, while in Europe the industry of the valuable by-products earn hundreds of millions every year, and have had the tendency to keep the prices of the natural liquid fuels on a lower level.

All the conditions I have alluded to seem to be changing rapidly now; this terribly wasteful performance begins to be recognized, the competition has become more keen, and a conservation of natural resources is striven for more than ever before. If this is true, the high-class engines with the highest efficiency will begin on this side of the ocean to have the same importance as abroad. In conclusion, I hope that I have succeeded in giving a true and clear picture of the development of the Diesel engine in Europe, with a few reminiscences of the pioneer work in America. Nowhere in the world are the possibilities for this prime mover as great as in this country.

FOREIGN REVIEW

BRIEF ABSTRACTS OF CURRENT ARTICLES IN FOREIGN PERIODICALS

CONTENTS

FOREIGN REVIEW

The aim of the Foreign Review is to present, within the available space, the main data contained in the articles indexed. Where possible, reference is made to English or American publications containing fuller information on the subject treated. Measures are given both in original units and their English equivalents. In many instances, engravings and tables are reproduced. Opinions expressed are those of the reviewer, not of the Society. Articles are classified as *c* comparative; *d* descriptive; *e* experimental; *g* general; *h* historical; *m* mathematical; *p* practical; *t* theoretical. Articles of exceptional merit are rated *A* by the reviewer.

Aeronautics

Versuchseinrichtungen zur Prüfung von Luftschrauben, P. Bejeuhr. *Dinglers polytechnisches Journal*, April 6, 1912. 3 pp., 8 figs. *dh.* Description of various appliances for *testing aerial propellers*, with some historical information on the development of this branch of testing.

Air Machinery

Filtres à air pour turbo-générateurs, compresseurs et autres machines. *Électro*, March 1912. 2½ pp., 5 figs. *d.* Discussion of the use of air filters with turbo-blowers, compressors, etc., and description of the Schütz filter.

Elementare Berechnung der Turbo-Gebläse und Kompressoren, R. von Stein. *Dinglers polytechnisches Journal*, April 20, 1912. *t.* Beginning of a series of articles on elementary methods of designing turbo-blowers and compressors, without the use of entropy diagrams. An account will be given later.

Wirkung von Ventilatoren und Kapselgebläsen, G. Lindner. *Zeits. für Dampfkessel und Maschinenbetrieb*, April 5, 1912. 2½ pp. 10 figs. *tA.* Hydrodynamic equations cannot be applied to the *calculation of ventilators and rotary blowers*, because, first, the density of the air is not constant like that of water, and, second, the flow between the blades of the rotor is unknown, the tendency being for the stream of air not to follow the curvature of the blade, but to press closer against the driving surface. The energy communicated to the air by the fan can therefore be calculated only approximately, while its blast capacity cannot be calculated from the form and speed of rotation alone at all.

Theoretically the gain of energy can be expressed (2, Fig. 1) in meters of air by the formula

$$H = \frac{\omega}{g}(v_2 r_2 - v_1 r_1)$$

where $v = \omega r - w tg\epsilon$ is the tangential velocity of the air, w its radial velocity, and $tg\epsilon$ is somewhat larger than at the vanes. To make this formula more convenient for practical purposes, the author expresses it in millimeters of water by multiplying it by the specific gravity of air $\gamma = 1.25$ kg/cbm (therefore $\frac{\gamma}{g} = \frac{1}{8}$, and $\frac{\sqrt{2g}}{\gamma} = 4$), and introducing $u_2 = \omega r_2 = u$, as well as $w_1 = w_2 = \left(\frac{r_1}{r_2}\right) c$, where c is the velocity of flow in the neck of the nozzle. He obtains finally the formula

$$H' = \frac{1}{8} u^2 \left[1 - \left(\frac{r_1}{r_2}\right)^2 + \frac{w}{u}\left(\frac{r_1}{r_2} tg\epsilon_1 - tg\epsilon_2\right)\right] - \psi u^2$$

where the factor ψ depends on the construction of the blower wheel, but varies somewhat with the flow in accordance with the vane angle. For $c = 0$, and $\frac{r_1}{r_2} = 1/2$ or $1/3$, $H_o' = 0.09u^2$ or $0.11u^2$ respectively.

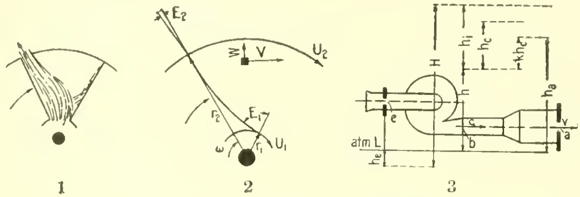


Fig. 1 Air Blower Diagram

To determine the blast capacity, the resistances in the blower have to be replaced by equivalent throttling areas, such as the orifice e in case of a suction fan (3, Fig. 1), or a similar orifice a at the pressure side in case of a blower. The throttling in e destroys a part of the atmospheric pressure in the suction chamber, and diminishes the total pressure by the amount h_e. There is a static pressure above atmospheric h on the other side, as well as velocity head h_c corresponding to the velocity c in meters per second of flow in the neck of the nozzle of cross-section b in square meters. A fraction k of this velocity head is utilized for the flow through the orifice a, and the efflux velocity at a, with efflux coefficient μ, is a function of the pressure $h_a = h + kh_c$. The capacity of the efflux is therefore

$$Q = .cb = a\mu \sqrt{\frac{2\,gha}{\gamma}} = 4\mu a \sqrt{ha} = e\mu \sqrt{\frac{2\,hge}{\gamma}} = 4\mu e \sqrt{h_e}$$

This equation shows also the necessary ratio of throttling $\frac{a}{b} = \frac{C}{4\mu\sqrt{ha}}$; if we accept $c = \sqrt{d}$ where d in mm is the internal diameter of the pipe fully satisfying practical demands and conditions of operation, and $\mu = 0.8$ for orifices of average size, Table 1 gives practically acceptable values for $\frac{a}{b}$.

In general blowers for high pressures have $\frac{a}{b}$ equal to 1/6 or 1/4, and those for large blowing capacity $\frac{a}{b}$ equal to 1/4 to 1/2.

The energy H of the blower wheel is not equalized entirely by the static pressure above atmospheric h_e+h, and the difference h_i goes to overcome the internal resistances in the machine, and to produce the flow of air. It is convenient to express the flow in terms of the known cross-section of the neck of the nozzle b,

TABLE 1 VALUES OF $\frac{a}{b}$ FOR VARIOUS ORIFICES

d (mm)	c (m per sec.)	$h=100$	400	900 (mm of water)
			$\frac{a}{b}$	
100	9 to 10	0.30	0.15	0.10
250	14 to 16	0.50	0.25	0.15
400	18 to 20	0.60	0.30	0.20
1000	30 to 33	1.00	0.50	0.30

and to introduce a coefficient v to take care of the resistances in the blower. Then

$$c=v\sqrt{\frac{2g}{\gamma}h_i}=4v\sqrt{h_i}=4v\sqrt{\frac{H}{1+\left(\frac{vb}{\mu a}\right)^2+\left(\frac{vb}{\mu e}\right)^2-kv^2}}$$

where for $h_i=H-h_e-h$ is substituted its value from the above equations.

The coefficient $v=\mu\frac{a}{b}\sqrt{\frac{h}{H-h}}$, together with the coefficient ψ, are the two characteristic constants which can be found by testing, and which permit the calculation of the pressure and blowing capacity of a blower under all conditions of operation, if e or a are known.

The article contains also a discussion of the influence of a *diffusor*, and a method, similar to the above, for the calculation of the *efficiency of a rotary (Root's) blower.*

Firing and Furnaces

Der Irinyi-Ölbrenner für Öl-Feuerungsanlagen, Dr. S. *Gesundheits-Ingenieur*, April 6, 1912. 1½ pp., 3 figs. *d.* Description of the *Irinyi oil-burner*, and data of tests lately finished, but not yet published, by Professor Josse at the Charlottenburg Technical High School. The burner casing a (Fig. 2) is provided in its upper part with the slot f, under which is placed the retort-shaped carburetor b, having the fuel brought to it by the pipe c. Under the carburetor is placed the tray d for the initial heating fuel. The fuel flows direct into the carburetor placed in the hottest part of the furnace, and arranged so that there can be no possible back-firing into the

carburetor. The fuel is there rapidly evaporated, no air being present, the evaporation being accelerated by the foaming and expansion due to the presence in the fuel of the lighter oils. On coming from the carburetor the vapor mixes with the air drawn in by the draft in the stack, and gives a hot flame varying from red to blending white, with clean, sharp edges, free of soot. The burner can use practically any kind of liquid fuel, naphtha, naphthalin, or any of the coal-tar oils.

Professor Josse in his tests found that a burner with a carburetor of 60 mm to 80 mm (2.36 to 3.14 in.) in diameter burned without residue from 1.2 to 15 and even 20.1 (0.32 to 3.95 and even 5.3 gal.) per hr., with no coke residue noticeable. The temperature of the flame, with admission of fresh air, varied normally between 700 and 1200 deg. cent. (1292 and 2192 deg. fahr.), but by admission of preheated air any temperature employed in oil firing could be obtained. The analysis of the gases of combustion has shown the content of CO_2 as high as 13½ per cent, or an efficiency of 85 to 90 per cent, with a great regularity in the working of the burner. In fact, it is

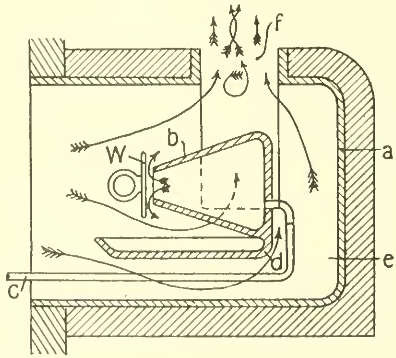


Fig. 2 Irinyi Oil-Burner (Mark the absence of nozzles)

claimed that trouble can arise practically only owing to impurities in the fuel, and this can be eliminated by straining.

Die Regelung von mit flüssigem Brennstoff betriebenen Feuerungen, Dr. G. *Petroleum*, March 20, 1912. 1 p. *d.* Description of an *air supply regulator for liquid fuel furnaces*, arranged so that the governor of the motor driving the blower is regulated in accordance with the pressure in the oil piping in such a manner that the rotation of the blower is speeded up or retarded respectively as the oil pressure increases or decreases. The proportion of air and oil in the furnace is therefore constant under all conditions of working. The oil pump is driven by steam, and in its turn drives the oil into the pressure piping. The pressure in this piping depends on the pressure and amount of the steam entering the pump, and acts on the piston of a reduction valve in such a manner that as the pressure in the oil pressure piping increases or decreases, the piston is pressed down more or less, whereby a larger or smaller amount of steam, of higher or lower pressure,

is let through the reduction valve to the engine driving the blower, and this correspondingly affects the output of the blower so that at higher pressure in the oil piping the blower supplies a larger amount of air to the oil nozzle.

The article also describes *automatic air regulation for locomotives using liquid fuel* patented in Austria by von Madeyski and von Krobicki (the pressure in the furnace is used for regulation, with a movable piston placed in the wall of the furnace or a fire door).

Hydraulics

DIE BERECHNUNG DER FLÜSSIGKEITSREIBUNG IN SAUGROHREN, DÜSEN UND ZELLEN VON TURBINEN UND PUMPEN UND DEREN EINFLUSS AUF DEN WIRKUNGSGRAD, V. Kaplan. *Zeits. für das gesamte Turbinenwesen*, February 29, March 10, 20 and 30, 1912. 11 pp., 11 figs. *tA*. Calculation of *friction in draft tubes, nozzles and buckets of water turbines and pumps and of its influence on the efficiency.* The author shows that the usual method of considering friction losses as a certain percentage of the total drop without regard to the area and form of the cross-section of the respective passages may easily lead to quite misleading results, especially in the design of new units. He therefore establishes certain formulæ for the calculation of frictional resistance of water in conical draft tubes and nozzles on one hand, and runners and distributors on the other. To do this the author starts from Biel's empirical formula for the calculation of loss of pressure head in flow of water

$$h=\frac{lc^2}{R}\left[a+\frac{f}{\sqrt{R}}+\frac{b}{c\sqrt{R}}\frac{\eta}{\gamma}\right]$$

where h in mm. of water is the loss of head due to friction; c the mean velocity of flow in m. per sec.; l length of the tube in m.; R hydraulic radius expressed as the ratio of area of cross-section of tube in sq. m. to its circumference in m.; a the so-called "fundamental coefficient" (*Grundfaktor*) which, according to Biel, may be taken to be constant and equal to 0.12; f coefficient of roughness, equal to: for turbine passages 0.015, and for ordinary cast-iron and wrought iron pipes 0.019; the last element is intended to represent the variable (with temperature) viscosity of water, but in comparison with other factors may be neglected altogether according to Professor Kammerer's investigation. The author accepts therefore for his purposes the simplified formula

$$h=\frac{lc^2}{R}\left(a+\frac{f}{\sqrt{R}}\right)$$

from which h can be very easily calculated as long as the hydraulic radius R and velocity c remain constant. They are not constant, however, in conical nozzles, and the author derives somewhat complicated formulæ for this and similar cases, which he then applies to numerical examples. He proves that friction losses depend materially on the shape of the section through which the water flows, and shows how to find the friction losses at each point. He gives further a general solution for the problem of finding the friction losses in a passage of variable rectangular cross-section, investigates the influence of the number of vanes, and their length and height,

and proves the following general rules: (*a*) all other conditions being equal, vane friction grows in proportion to the length of vane; (*b*) when the number of vanes is doubled the friction is quadrupled; (*c*) when the width of entrance is doubled, the friction decreases more than four times; (*d*) in two geometrically similar wheels, that is, having geometrically similar buckets, the friction varies inversely as the diameter of the wheel; (*e*) a large number of vanes, even when they are very thin, have a material influence on decreasing the flow of water through the wheel; the same is true with respect to long vanes, and small entrance and discharge cross-sections. The author finally concludes that the highest degree of efficiency of a turbine or pump is reached when the least friction in the wheel and tubing is made coincident with a free-from-impact flow of water through the entrance and discharge passages of the wheel.

Internal Combustion Engines

Die Internationale Ausstellung von Verbrennungsmotoren in St. Petersburg. N. Bikoff and G. von Doepp. *Die Gasmotorentechnik*, April 1912. 6 pp., 14 figs. *d*. Continuation of the description of the *internal-combustion engines* at the International Exhibition at St. Petersburg. Description of the Gueldner engine and Richet gas producer built by the Kolomna works, Russia; the engine built by the Campbell Co., of Halifax, England, and the engine and Pierson producer of the Thomassen Co., of Arnheim, Holland, with data of tests of the last two types.

Versuchsprotokoll über die Vergasungsversuche mit Wackersdorfer Rohbraunkohle auf dem Stahlwerk Mannheim in einem patentiertem Drehrost-Gasgenerator System Hilger von 2100 mm lichtem Durchmesser. *Braunkohle*, March 29, 1912. 1 p. Data from tests of a Hilger Revolving Grate *Gas Producer with lignite coal containing* 52.7 *per cent moisture, and about* 60 *per cent culm.* There was obtained 1.6 cbm of gas per 1 kg of coal (25.5 cu. ft. per lb.), with an average lower heating value of 1100 Kal./cbm (say 125 b.t.u. per cu. ft.). The gas was found to be rich in moisture and tar, but comparatively poor in sulphur. The efficiency of the producer is claimed to be 80 per cent.

Versuche an einer Sulzerschen 300 pferdigen Dieselmotoranlage mit Abwärmeverwertung, J. Cochand and M. Hottinger. *Zeits. des Vereines deutscher Ingenieure*, March 23, 1912. 5 pp., 17 figs. *e*. Data from tests of a 300-hp. Diesel engine with the utilization of heat of exhaust gases in two water heaters of 30.24 qm (say 323 sq. ft.) heating surface. The article gives heat balances for the engine at various loads, as well as curves showing the mechanical efficiency of the installation, etc. These tests have shown that as much as 80 per cent of the heat contained in the fuel may be usefully employed.

Benzinmotor und Hochdruckzentrifugalpumpe der Frankfurter Feuerwehr in einem Dauerbetriebe, Schänker. *Der Motorwagen*, April 20, 1912. 1 p. *ep*. In the summer of 1911 the excessive heat forced the consumption of water in the city of Frankfort from 70,000 cbm to 110,000 cbm, an amount considerably in excess of what the machinery of the water works could deliver. There was however a well with good water avail-

able, but the water being 15 m (49 ft.) deep, and because of certain local conditions the use of a steam pump was very inconvenient. A rapid solution of the problem was required, and the city water works borrowed a 45-h.p. benzine motor and pump from the fire department, which was ordered by the latter, but not yet accepted. This was lowered into the well. The article gives full data of the rather unusual work of this fire engine plant, from which it is seen that the plant worked every day from August 1 to September 17, from 3½ to 23 hours a day, delivered during that time 65,939 cbm (say 2,320,000 cu. ft.) of water, and was in first class condition at the end of that period.

Ein Beitrag zur Lösung des Gasturbinenproblems, Lehne. *Die Turbine*, April 5, 1912. 1 p., 1 fig. *d.* Cp. Ein neuer Vorschlag für das Gasturbinenproblem, Jos. Schuch. *Zeits. für Sauerstoff- und Stickstoff-Industrie*, April 1912. 1½ pp. *d.* Both authors state that the main difficulty in the design of a successful turbine is the large consumption of power

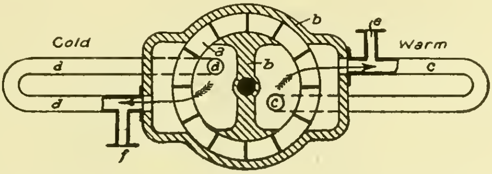


Fig. 3 Caloric Air Compressor for Gas Turbines

required by auxiliary apparatus for compressing the mixture. A new construction is therefore proposed, on the principle of the caloric engine, in which the compression of the mixture is to be obtained by preheating the air by exhaust gases. Fig. 3 shows diagrammatically the proposed construction: *a* is a wheel provided with cells opening inside and out, and revolving in a casing *b*. This casing is provided with suitably located passages which in connection with the pipes *c* and *d* form independently closed circuits. When the wheel is set into rapid rotation it acts like a centrifugal blower, that is, the air in the wheel flows outwards, so that the air contained in each of the cells is driven out and replaced by the air brought inside the wheel by the pipes *c* and *d*. The piping *c* is heated, and *d* cooled, and therefore the cold air goes from *d* to the wheel, and from there is driven to *c*, where it is heated and receives a corresponding increase of volume or pressure, the latter allowing part of it to escape through *e*, and in consequence the air entering the wheel from *c* does not have the same specific weight that it had before. Now when the air is cooled to its initial temperature in *d*, there is a fall of pressure and an aspiration of outside air through *f*. The warm air escaping through *e* goes to a cooler where it is cooled by decreasing its velocity of flow. Theoretically, by having a sufficient number of compression chambers, any degree of compression may be obtained. The wheel has to supply only the work required for making the air circulate, but the main work of compression is obtained by the application of the heat of exhaust gases. The author admits the existence of

constructive difficulties in the execution of this turbine, such as packing the wheel. It is evident from the general tenor of the article that no such turbine has ever been constructed.

Die charakteristischen Kurven der Dieselmotoren, A. Balog. *Die Gasmotorentechnik*, April 1912. 2 pp., 4 figs. *t.* Discussion and method of construction of *characteristic curves for Diesel engines.* By a characteristic curve, or simply characteristic, the author means a curve which, when suitably interpreted, would show the limits of application of an engine as regards working conditions and completeness of combustion. In testing a motor, attention is primarily directed to determining its consumption per h.p.-hr., *ge*, indicated average pressure *pi*, and general mechanical efficiency of the engine. These values are put in the form of a diagram with *Ne*, or effective horsepower, as abscissae. If the number of revolutions varies, a whole family of such curves is obtained. In Fig. 4 with *pi*, or average indi-

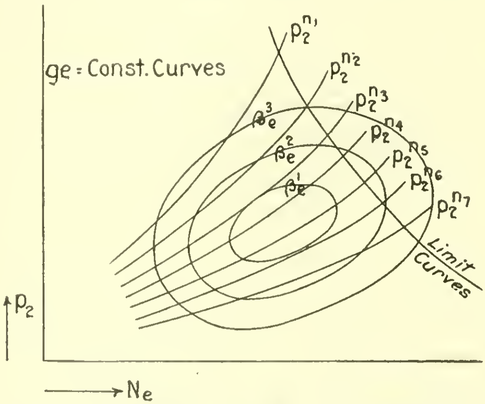


Fig. 4 Characteristic Curves of a Diesel Engine

cated pressures as ordinates, the number of revolutions for each set of determinations is taken to be constant, so that a separate *pi* curve is obtained for each number of revolutions. On each curve are marked the points where the values of *ge*, or consumption per horsepower-hour, are equal. If such corresponding points on all curves be connected, new curves, of equal consumption per horsepower-hour, are obtained. These *ge*-constant curves must of course be closed, and cannot intersect each other. By testing the average pressure *pi* and combustion coefficient *ge* for given speed of rotation, points can be found at which smoke in the exhaust gases appears. If these points are plotted on the *pi* curves, and connected with each other, the smoke-curve is obtained indicating the limit up to which the engine has a practically complete combustion. In the same way useful curves may be drawn with *ge* as ordinates; these *pi*-constant curves are also closed curves which do not intersect. The author claims that these two sets of curves can show everything that is necessary to judge of the efficiency and quality of an engine. He gives in the article two sets of curves based on the data obtained from the tests of Diesel engines by Eberle and Seiliger.

Kraftgasgeneratoranlage mit wechselweisem Verkokungsbetrieb für bituminöse Brennstoffe. H. L. Braunkohle, April 12, 1912. 3 pp., 5 figs. *d.* Description of a *power gas producer*, patented by Wangemann, and invented by the German engineer M. Ziegler, *in which bituminous fuels*, like peat, lignite, etc., *are treated for gas and coke in separate chambers* placed side by side, and always used for the same purpose (contrary to another type where the chambers are used alternately for gas production and coking). This arrangement permits either of the use of the gases formed in the hottest part of the gas producer chambers for heating the coking chambers or of conducting to the producer shaft the product of incomplete combustion from the coking chambers. The plant is supposed to be used primarily in places where the demand for power on the gas engine is intermittent, as e. g., in central station work when the demand for gas for the engines is small, and the plant is still working at its full capacity, only in making coke.

The cycle of operation of such an installation is as follows: The fuel is placed in the upper part of a very tall producer shaft, and entirely freed from moisture and tar; the coke is then further gasified in the lower part of the producer. To enable the plant to produce alternately coke or gas, suitably arranged chambers are so connected with each other that the gasifying chambers are provided, above the zone of incandescence, with ducts for the passage of gases, which first heat the walls of the coking chamber, and then pass into it. When the process is reversed, and the plant works as a gas producer, the same arrangement permits the full utilization of the products of incomplete combustion of the coking chamber. The article contains a detailed description of the plant with drawings. The following shows the output of the plant as gas producer and coking plant.

As a coking plant. It can treat in three coking chambers 600 kg (1320 lb.) of peat, with 25 to 30 per cent moisture, and the following production per hour:

	Kg.	Lb.
Peat coke	200	440
Ammonium sulphate	2.4	5.3
Methyl-alcohol	1.2	2.6
Peat-tar	20	44
Asphalt	20	44

and besides, 120 cbm (4200 cu. ft.) of gas, with heating value 2400 WE/cbm, or 270 b.t.u. per cu. ft. In the second coking an additional 100 kg (220 lb.) of peat is treated per hour, giving 23 kg (56 lb.) of peat coke and 20 cbm (say 700 cu. ft.) of gas. The producer and peat tar can be further treated, and give 5 per cent benzine, 75 per cent Diesel motor oil, and 10 per cent paraffin.

As gas producer. Four gas producer chambers can treat 2000 kg (2.2 tons) of peat with 25 to 30 per cent moisture; 1000 kg (2200 lb.) of such peat with about 1 per cent nitrogen give about 2000 cbm (say 75600 cu. ft.) of gas, with heating value 1200 WE per cbm (say 136 b.t.u. per cu. ft.). Since a large gas engine requires about 2.5 cbm (88 cu. ft.) of such gas per h.p.-hr., the amount of gas produced is sufficient for 1600 h.p. or 1176 kw.

As by-products about 40 kg (88 lb.) of ammonium sulphate, and 20 kg (44 lb.) of producer tar are obtained.

Gassogeno per gas povero a combustione rovesciata. L. Jacobitti. *L'Elettricista*, April 15, 1912. 3 pp., 1 fig. *d.* Description of a new *gas producer* invented by the author of this article. The fuel is charged through suitably arranged hoppers from above. Immediately below the charging space is the combustion zone provided with an inclined grate; the fuel is burned in a restricted space at a high heat with the admission of air and steam. *The gases being drawn downwards*, have to pass a second incandescent zone with the grate inclined at an angle of 90 deg. to the grate in the first zone, and then a third zone, with the grate parallel to that in the first zone, where all the carbon dioxide is reduced to carbon monoxide. On coming out from this part of the producer, the gas presumably consists of hydrogen, non-condensible hydrocarbons rich in hydrogen, carbon monoxide and nitrogen. The amount of steam required for this producer is said to be very small. The main peculiarities of this producer are: the gases travel downward just as the fuel; the products of distillation have to pass through the whole mass of incandescent material which results in the complete combustion of the coal previously freed from all volatile constituents; the coke required for the reduction is furnished by the upper part of the producer itself.

Machine Design and Machine Parts

Rapport sur les Courroies "Titan" en cuir armé système Magaldi, L. Masson. *Bulletin de la Société d'Encouragement pour l'industrie nationale*, March 1912. 13 pp., 12 figs. *dg.* Description and general discussion of the Titan belts, based on data furnished by the manufacturers. These belts are made of thongs of leather connected into strips of equal breadth, the strips in their turn being interconnected in pairs by staggered metal members. It is claimed that such a belt forms no air cushion, is very strong and flexible. No data of tests are reported in the article.

La lubrificazione delle machine utensili, G. Rinder. *L'Industria*, March 31, 1912. 1 p., 2 figs. *p.* Inefficient *lubrication in machine tools* is the principal cause of their rapid decay. It is the secondary parts which get out of order most easily, chiefly because the main parts are provided with sufficient and continuous lubrication, while the secondary parts are left to be lubricated by the workman squirting oil through a hole in the frame from time to time. But the hole becomes clogged with dirt, and the workman, who does not possess now that love of his machine which made him formerly anxious to keep it in good order, is apt to let it run dry, and spoil it. That did not matter much as long as the speeds were low, and power small, but is a very important factor under the present conditions. Some American manufacturers are beginning to construct machine tools with automatic lubrication throughout, but this practice is not yet as general as it ought to be.

Machine Shop

Fraiseuse horizontale, P. B. *Portefeuille économique des machines*, April 1912. 2 pp., 7 figs. and 1 plate of drawings. *d.* Description, with de-

tailed drawings, of a *milling machine* constructed by the Société Française des Constructions mécaniques, of Denain, France. This machine is designed to work any surface independent of its shape or size. It has a cutter rotating about a horizontal axis parallel to the plane of the machine, and cut either from one block of special steel, or made in parts with inserted teeth, and either cylindrical, or of irregular shape. The use of such a cutter permits not only of cutting over the whole surface, but of taking a very deep cut, and giving at once the desired shape to the surface milled.

PLAQUES-RESSORTS, POUR PRÉVENIR LE DESSERAGE DES PIÈCES ASSEMBLÉES PAR BOULONS. *Le Génie Civil*, March 30, 1912. *d.* These *washer-springs* (Fig. 5) are made of three pieces of spring steel welded together in the form of a triangle with a hole inside just large enough to let the bolt pass, but without giving it much play. They very strongly *resist all tendency of the bolt to get loose*, and J. Reiss found that it required a power of 1500 kg (3300 lb.) to flatten a washer weighing only 55 g (1.2 lb.).

DIE THEORIE DES SCHWEISSENS VON STAHL UND IHRE PRAKTISCHE ANWENDUNG. Max Bermann. *Zeits. des Vereines deutscher Ingenieure*, March 30, 1912. 7 pp., 14 figs. *etA.* An attempt to construct the whole *art of welding* on the basis of the *theory* that the metallic contact of the smallest particles constituting the surfaces welded together is achieved through the reducing action, at the temperature of welding, of the constituent parts of steel.

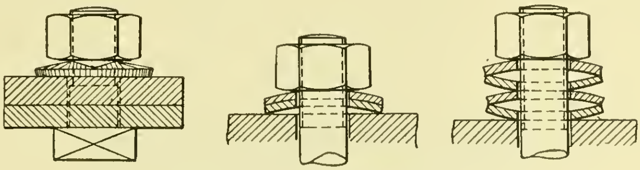


FIG. 5 J. REISS WASHERS-SPRINGS

The welding properties of steel are above all affected by the carbon content: the greater the carbon content, the less weldable is the steel, and it becomes entirely unweldable when the carbon content passes a certain limit; in the last case the reducing agents available are not sufficient to reduce all the oxides present, and the steel flies to pieces when hammered at a white heat. When, as happens sometimes, wrought iron behaves like hard unweldable steel, it means simply that under some favorable conditions it became case-hardened and so converted into hard steel. Manganese improves the welding properties of steel, but only when present as free manganese or a carbide, but hinders it when present in the form of manganese oxide. Silicon favors welding by reducing the manganese oxide, and raising the temperature of welding. Phosphorus in small amounts helps to maintain the high temperature required for welding, and thus coöperate with silicon.

The temperature of welding is the highest temperature at which steel is still malleable. The pressure required for cohesion at the temperature of

welding is slight, but after the cohesion has been effected, the blows or pressure on the two pieces must be considerable, in proportion to the size of the pieces and area of surfaces welded.

The article contains also some practical hints for welders, and a detailed discussion of autogenous welding.

Eine Vorrichtung zum Pressen von Rohren und gleichzeitigem Ueberziehen ihrer Innenwandung mit einem anderen Metall. *Metall-Technik*, March 30, 1912. ½ p., 1 fig. *d.* Description of a process patented in Germany by the Felten & Guillaume Carlswerk Co. of Carlswerk in Mühlheim a. Ruhr, Germany, for *covering the inner surface of a pipe with a metal at the time of making the pipe itself.* As shown in Fig. 6, *a* is a conical die provided with a hollow mandrel *c*, over which the lead mass *b* is pressed into a pipe *b′*. The mandrel *c* engages into the die *d* the inner diameter of which determines the outer diameter of the pipe *b′*. On the hollow mandrel *c* is made a groove *e* connected with the inside of the mandrel by radial channels *i*. The fluid metal with which it is proposed to

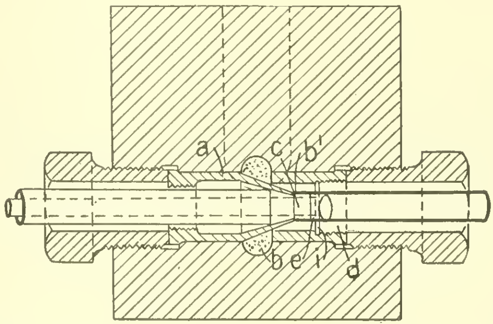


Fig. 6 Felten and Guillaume Process for Inside Tinning of Lead Pipes

cover the inside of the pipe is driven under high pressure into the hollow mandrel, and being thrown with considerable force through the ducts *i*, uniformly covers the inner surface of the pipe. Since at the time of the formation of the pipe it presents an absolutely clean metallic surface, and the mandrel prevents all access of air, the two metals unite under the most favorable conditions. The thickness of the metal cover, say tin, may be regulated by varying the depth of the groove *e*. This process may be applied to the manufacture of pipes of any length provided the pipe is made of metal that can be drawn.

Mechanics

Sur le temps de démarrage des moteurs à volant, Ch. Reignier. *Comptes rendus de l'Académie des Sciences*, March 18, 1912. 2½ pp., *t.* The author shows mathematically that *the time θ for starting a motor with a flywheel* (i. e. for bringing its speed of rotation from zero up to its normal speed V) cannot be less than a certain definite minimum for each particular case, or there will be danger

of breaking the arms of the flywheel, or the shaft of the motor. He further shows that if the curve of starting the motor is a simple half sinusoid, the arms of the flywheel are subjected to maximum tension at the end of a time ρ shorter than θ, i. e. before the motor reaches its normal speed. The author applies his method to the calculation of the stress in the arms of a flywheel of 14,000 kg (say 31,000 lb.) weight of rim, on a 275-h.p. engine, at various moments between 0 and θ, from the time of starting.

Zur Theorie der Reibung geschmierter Maschninenteile, L. Ubbelohde. *Petroleum*, April 17, 1912. 6 pp., 5 figs. *etA*. Investigation of friction in lubricated machine parts. The author in the first place proves that the wetting of journals and bearings, and the dimensions of the angle of contact are of the greatest importance in determining the lubricating qualities of a fluid. He thus introduces the consideration of capillarity. The lubricating oil forms between the bearing and journal a thin layer, the behavior of which may be investigated by means of two watch glasses. If a drop of oil is placed in one glass, and another glass of somewhat greater curvature pressed above it, the oil film may be made as thin as desired; but if we try to do the same thing with a drop of mercury, it will jump out on one side and let the air in on the other. The explanation

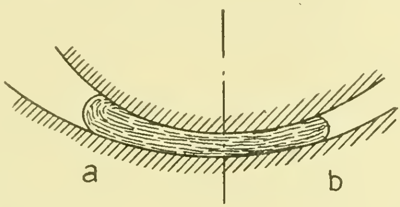


Fig. 7 Mercury Drop Under Pressure between Two Watchglasses

of this phenomenon may be found by considering the surface tension at a and b (Fig. 7), supposing that for some reason the distribution of the mercury is not uniform throughout, but that the space at b is narrower than at a. Since, however, the angle of contact is practically equal at both places, the radius of curvature at b must be smaller, and the pressure exerted by the upper glass greater than at a; the meniscus at b therefore drives the mercury to the left sufficiently to overcome the pressure at a. The mercury appears to have a "horror of narrow places." In the case of a fluid, such as oil, wetting the surrounding walls, an opposite phenomenon takes place, because (Fig. 8) in the more curved place at b the liquid is also subjected to a suction to the right which acts until the liquid is uniformly distributed in the narrowest place. In other words, the wetting liquid strives to fill the narrowest place, and this effort is so strong that under certain circumstances the liquid prevents the contact of the two contiguous surfaces. If there are air bubbles in the liquid, their behavior depends on the character of the liquid. In mercury they are driven into the narrowest space, in oil they are driven away from it.

Since, further, the capillary forces in the case of very thin films act with great strength, it follows that in using as lubricants liquids which do not wet the lubricated surfaces, there can never be any certainty that there is a liquid between

the rubbing areas. There is, on the contrary, reason to believe that there will be no liquid between them, and liquids which do not wet the surfaces in friction must not be used as lubricants. Fig. 9 shows the apparatus used by the author for investigating the capillarity of lubricants. It consists of two metal rings with watch glasses in them, and screws for bringing the rings more or less together, thus varying the pressure on the lubricant.

The author shows further, partly by a discussion of former experiments, partly

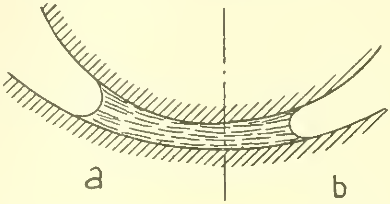


Fig. 8 Oil Drop Under Pressure between Two Watchglasses

by reference to his own observations, that *the external friction*, that is, the friction between the liquid and the contiguous solid surface, is independent of the degree of wetting and of the angle of contact, but has always to be accepted as being infinitely large, since all liquids adhere to all solid substances. External friction may therefore be neglected altogether in deriving the hydro-dynamic resistance in lubricated machine bearings, and only the viscosity of the liquid has to be considered. The author shows further that the deductions made from the experiments of Claudy on the properties of lubricants are erroneous, that there is no need for such a thing as the coefficient of adhesion derived by Claudy; that what Claudy called "capillary viscosity" is nothing but the viscosity of the liquids as compared with that of water, and that the specific viscosities of the

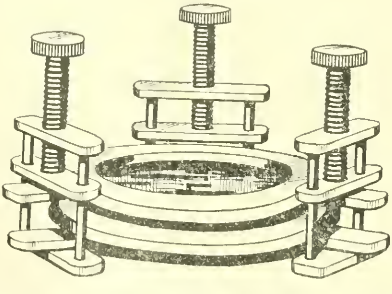


Fig. 9 Ubbelohde Apparatus for Testing the Capillarity of Lubricants

liquids agree better with Claudy's capillary viscosities than the latter do with each other.

The article contains also a discussion of the physical theory of friction between solids and between solids and liquids. It is to be continued.

Die Bertran-Kette. *Der praktische Maschinen-Konstrukteur*, April 25, 1912. 1 pp., 6 figs. *d.* Description of a new type of silent chain called the Bertran

chain, consisting of articulated members so arranged that in a certain position the *chain acts as a rigid rod.* In Fig. 10, 1 and 2 show the form of the links. In 3 and 4 the joint guides *d* and coupling *b* are shown engaging in the pin-holes *c*, which makes the chain perfectly rigid.

Steam Engineering

Die Berechnung der Dampfturbinen mit Hilfe des spezifischen Gefälles, Guido Zerkowitz. *Zeits. für das gesamte Turbinenwesen,* March 20 and 30 and April 10, 1912. 10 pp., 10 figs. *tA*. The author shows how a *steam turbine can be designed on the basis of a few auxiliary constants, particularly the specific*

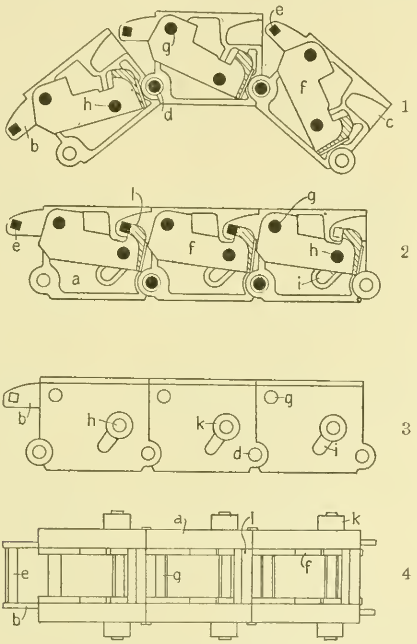


Fig. 10 The Bertran Silent Chain

drop k and mean square of peripheral speed. Among other things, in all cases with these constants the number of stages may be calculated, and all turbo-machines may be classified according to their specific drop *k* ("the number of stages in different systems are related to each other directly as the 'specific sum of squares' (*spezifische Quadratsumme*), or inversely as the mean value of the specific drop." The author introduces the conception of specific sum of squares, equal to the reciprocal of the mean specific drop, as relating to the whole turbine, while specific drop as such may vary from stage to stage). There is further a connection between the specific drop and the efficiency of the turbine η. The specific drop remains constant as long as the efficiency is constant. As regards actual efficiency the author points out that the influence of mechanical losses such as imperfect joints is of more weight in small installations than in large

ones, and that is the most important reason why small turbines are comparatively uneconomical. In the case of water turbines and pumps the specific drop is also a constant, characterizing the behavior of the engine, and it is not correct to compare pumps on the basis of available pressure heads, since by doing so the dimensions of the engine and its speed of rotation are left out of consideration.

In the second part of the article the author applies his method to the designing of a steam turbine with given specific drop and mean square of peripheral speed, as well as to recalculation of actual installations on the basis of tests by Professors Stodola and Lewicki.

Turbo-Kesselspeisepumpe. *Dinglers polytechnisches Journal*, April 20, 1912. $2\frac{1}{2}$ pp., 3 figs. *d*. Describes a turbine-driven feed-water pump built by the German General Electric Company. It is a single-stage centrifugal pump

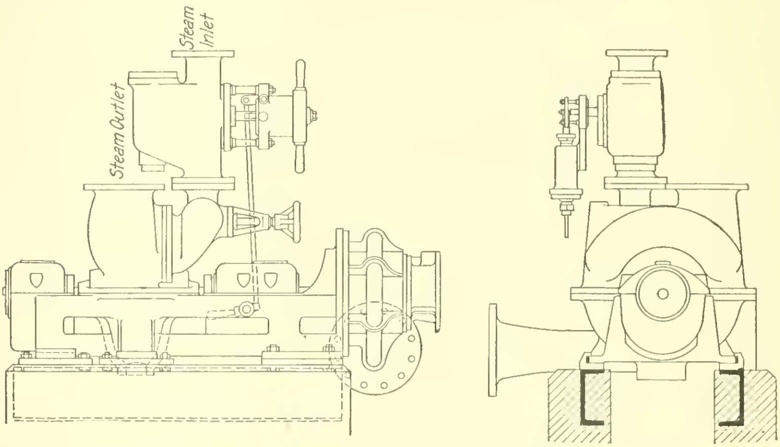


Fig. 11 Turbine-Driven Feed Water Pump of the German General Electric Company

capable of delivering water at a pressure up to 25 atmospheres. The driving turbine shaft (Fig. 11) lies on two bearings which, together with the lower half of the turbine casing and the bearing casings, form part of one bed-plate, fixed flange-like at the admission side, and carrying also the pump casing, with the safety governor located in a casing between the pump and the turbine. The governing of the pump is so arranged that the water pressure remains nearly constant, and the number of revolutions is automatically regulated in accordance with the demand for water. This is effected by means of a differential piston moving in a special casing, and having one of its sides acted on by the steam pressure from the throttling valve or direct from the boiler, and the other side open to the pump pressure. Both pressures must be equal, and should the pump pressure be greater, the piston will be forced away from it, and act on the throttling valve in such a way as to change the speed of rotation of the turbine. When the pump pressure falls off, the steam pressure forces the piston back, the throttling valve opens, and the speed of the turbine goes up.

The pump is single stage, with an overhung wheel set on the extension of the turbine shaft. The water enters the wheel axially, and is carried along pressure vanes disposed sidewise along the spirally shaped casing of the pump. The turbine stuffing-boxes are simple and are made of special steel set direct on the shaft, and provided with grooves for packing. The following advantages are claimed for this pump: small space required; low initial cost; practically no attendance required; absolute equalization of pressure in the pump; noiselessness and reliability of operation; automatic regulation of the speed of the turbine in accordance with the demand for water. The pump can work in parallel with a plunger pump, or the two may be connected in such a way that one begins to work as soon as the other is overloaded.

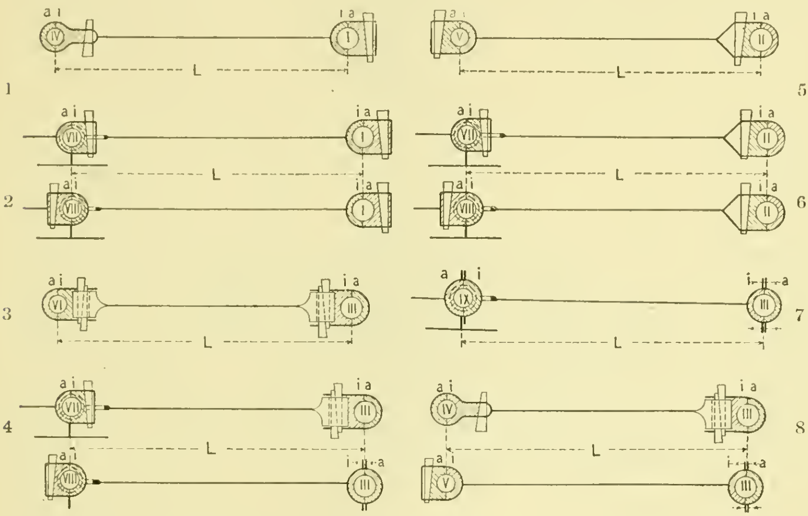


Fig. 12 Various Arrangements of Adjusting Devices in Connecting Rod Heads and Crossheads

Die Anordnung der Nachstellvorrichtungen in Schubstangen- und Kreuzköpfen, A. Wildometz. *Der praktische Maschinen-Konstrukteur*, April 11, 1912. 2 pp., 8 figs. *t*. Exposition of the methods of installing *adjusting devices for connecting rod heads and crossheads*. The requirement for a correct adjustment is that it should not change the dead centers of the piston with respect to the cylinder. Table 2 and Fig. 12 show how the adjustment affects the length of the connecting rod and the position of the piston. The length of the connecting rod L is measured as the distance from the center of the crankpin to the center of the crosshead pin. The external brass (i. e., the one lying beyond the length L, or outside of the two pins) is designated by a, the internal by i. The arrow pointing to the right indicates the displacement of the piston towards the crankshaft, the other arrow its displacement in the opposite direction.

Connecting rods with closed heads at both ends. In 1 is shown a connecting rod with heads as indicated. If the head I requires an adjustment owing to the brasses *a* and *i* being worn, the brass *i* will have to be brought closer to the crankpin (which is considered fixed), and therefore the head I will move to the right, and draw after it the crosshead and piston, which in its turn will lead to shortening of the rod and displacement of the piston towards the crankshaft. Should an adjustment of the brasses be made in head IV *a* will approach the crosshead pin, the rod will be lengthened, and the piston moved from the crankshaft. Therefore the change in the length of the connecting rod produced by adjusting the brass *i* in head I can be at least partly compensated for by the adjustment of the brass *a* in head IV, and if both these brasses have worn equally, the length of the connecting rod and position of the piston will not vary at all. The same would happen with the connecting rod shown in 5. But if the rod had on one side head I, as in 1, and on the other side head V, as in 5, an adjustment

TABLE 2 CROSSHEAD AND CONNECTING-ROD HEAD ADJUSTMENT

Kind of Head	No.	Form of Head	*L* after Adjustment		Place-Displacement of Piston in Adjustment	
			a	*i*	*a*	*i*
Connecting-rod head crankshaft side	I	Closed head, external adjustment	=	<	0	→
	II	Closed head, internal adjustment	>	=	←	0
	III	Open head, internal adjustment	=	<	0	→
Connecting-rod head, crosshead side	IV	Closed head, internal adjustment	>	=	←	0
	V	Closed head, external adjustment	=	<	0	→
	VI	Open head, internal adjustment	=	<	0	→
Crosshead	VII	Closed head, internal adjustment	=	=	→	0
	VIII	Closed head, external adjustment	=	=	0	←
	IX	Open head	=	=	→	0

of both inner brasses would make the rod shorter, and doubly displace the piston towards the crankshaft. Equally unsatisfactory would be the case of a rod provided with heads II and IV, as can be seen from the table. This permits of a *general rule* of having *in rods with closed heads at both ends the adjusting devices always on the same side of both pins.*

Connecting rod with closed head on the crank side and forked end in closed crosshead. In this form the crosshead pin is placed in the fork-shaped end of the connecting rod, with the brasses and adjusting devices in the crosshead itself; the adjustment, whether external or internal, does not therefore affect the length of the connecting rod, but there can be a displacement of the piston, towards the crankshaft in case VII, and the other way in case VIII. In order therefore that the piston should not change its dead centers, the connecting rod with closed head and external adjustment must connect with a closed crosshead with external adjustment, as shown in the upper part of 2, but the arrangement in the upper part of 6 is also correct, because there the connecting rod has an in-

ternal adjustment. An interesting feature of these two correct arrangements is that, provided the wear of the brasses is equal at both ends, there is no displacement of the piston owing to adjustments, even though there may be a change of length L. The following general rule therefore holds good for this class of connecting rods: *in connecting rods with closed head on the crank side, and fork-shaped end of connecting rod in closed crosshead, the adjusting devices must be on different sides of the pins, but both either external or internal.*

From the table and 4 it may be seen that *in connecting rods with open head, and*

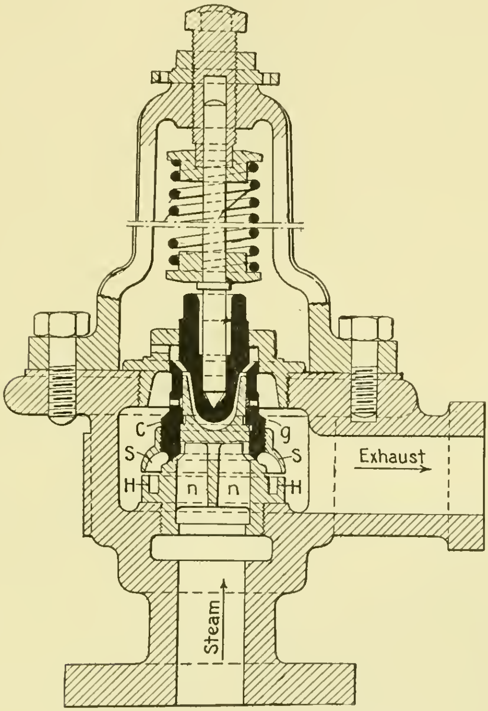


Fig. 13 Maneby Safety Valve

crosshead pin in closed crosshead, the adjusting device in the crosshead must always be external.

Connecting rod with open head on the crank side, and closed head on the crosshead side. As seen from the table, the upper arrangement in 8 is correct because an adjustment does not produce either change of length of rod or displacement of the piston, as would be the case with the lower adjustment: *the adjusting devices must therefore always be internal.*

Connecting rod with both heads open must not be used at all, because both III and VI produce shortening of the rod and displacement of the piston towards the crankshaft. The arrangement shown in 7 is also bad, because the crosshead

and piston rod are forged in one piece, and an adjustment produces displacement of the piston towards the crankshaft.

The above may be expressed in the following four general rules: (*a*) with closed heads external adjustment produces lengthening, internal shortening of the rod; (*b*) with open head internal adjustment produces shortening of the rod; (*c*) with closed crosshead internal adjustment produces a displacement of the piston towards the crankshaft, external in the opposite direction; (*d*) adjustment of the brasses in an open crosshead produces displacement of the piston towards the crankshaft.

Soupape de sûreté, système Maneby, à charge réduite et à échappement progressif. *Le Génie Civil*, March 30, 1912. ½ p., 2 figs. *d*. Description of a new *safety valve* designed by a Swiss engineer *Maneby*, and built on the principle of making the steam act on a narrow annular strip, so that a very light load is sufficient to counteract the boiler pressure. The two seats (Fig. 13) are placed horizontally, and connected by guide vanes n with the main seat H, so as to form practically one piece with the guide block g on the cylindrical part of which rests the valve C. Equalization of partial vacuum is effected by the reaction of the exhaust steam which strikes the inner curved surface of the bell S forming part of the valve, but adjustable as to height. The following advantages are claimed for this safety valve: (*a*) the load which must act on the spring at the moment of the opening of the valve, so as to balance the boiler pressure, is reduced to one-fourth or one-sixth of that usually required; (*b*) the partial vacuum produced at the moment of the opening of the valve is compensated for by the reaction of the exhaust steam striking the inner curved surface of the bell S, so that, with the amount of steam under this bell increasing as the valve rises, its rise is effected gradually until the end of its path, but as soon as the excessive pressure is relieved, the valve as gradually and without shock comes back onto its seat; (*c*) owing to the great output of these valves, their section of orifice need be only about one-third of that formerly adopted by the French practice, which permits of smaller dimensions and considerably lower cost of the apparatus.

Examen des recherches de M. Armand Duchesne sur les propriétés de la vapeur d'eau surchauffée, V. Dwelshauvers-Dery, *Revue de mécanique*, March 31, 1912. 20 pp., 14 figs. *etA*. Account of the experimental work on the *properties of superheated steam* by A. Duchesne at the Laboratory of the University of Liège. Duchesne used a special thermoelectric pyrometer invented by himself and called a *Hyperthermometer*, consisting of (Fig. 14) very fine (0.028 mm. in diameter) silver and platinum wires joined respectively to heavy wires of the same metal Ag and Pt, so that thermoelectric couples were formed only at the points where the fine wires were soldered together. The current was measured by a sensitive ballistic galvanometer, and a special arrangement installed to place the galvanometer in circuit only for a desired length of time, e.g., 1/10 of a second. The deflection of the galvanometer would then show the average temperature during that 1/10 of a second. By means of this hyperthermometer Duchesne found that only saturated steam has a definite temperature for a given pressure, and the same temperature for all points. In superheated steam there may be different layers at different temperatures, and there may even be points where the steam is saturated. He further found that in measuring

the temperature of superheated steam the mercury oil-bath thermometer is very unreliable. He found that there was a difference between the temperature as indicated by the hyperthermometer and that indicated by the mercury thermometer in an oil bath as high as 85 deg. cent. (153 deg. fahr.) at low pressure (17,084 kg/qm, or 24.2 lb. per sq. in.), falling to 43 deg. cent. (78 deg. fahr.) at the pressure of 66,930 kg/qm, or 95 lb. per sq. in. In general he believes that in many cases where the temperature has been measured by the mercury thermometer in an oil bath, the temperature of superheat is much higher than the measurement would indicate. Where a hyperthermometer cannot be used, an ordinary mercury thermometer placed direct in the steam will show the temperature with a correctness sufficient for most practical purposes.

As regards the *law of compressibility*, Duchesne establishes the following proposition: for a given pressure, beyond a certain limit of temperature, superheated

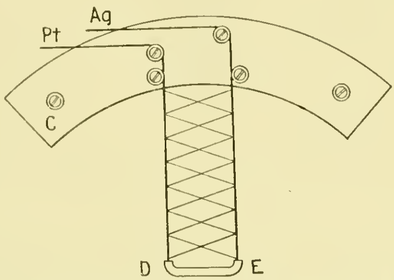


FIG. 14 DUCHESNE THERMOELECTRIC HYPERTHERMOMETER FOR MEASURING THE AVERAGE TEMPERATURE OF STEAM

steam obeys the law of Gay-Lussac, that is, at a constant pressure the product pv' is proportional to the absolute temperature T. Below this limit, down to the temperature of saturation, the law of compressibility is represented by a curve which has a point of inflection, and of which the form corresponds fairly well to a complete equation of the third degree. A general characteristic of superheated steam is that as the pressure increases, all its properties become independent of the pressure, and vary only as a function of the temperature.

The article contains also a full discussion of the variation of the specific heat of superheated steam.

KRAFTERZEUGUNG UND WARMASSERBEREITUNG, L. Schneider. *Dinglers polytechnisches Journal*, April 20, 1912. 4 pp., 12 figs. *c*. Discussion and comparison of various methods of combining steam power with steam heating. The author concludes that the most economical method is to take the steam from the receiver of a compound engine. Cp. the article on the same subject by Lecuir, *The Journal*, May, 1912, p. 789.

Strength of Materials and Materials of Construction

BIEGUNGSVERSUCHE AN GUSSEISERNEN STÄBEN, R. Schottler. *Zeits. des Vereines deutscher Ingenieure*, March 2 and 9, 1912. 12 pp., 29 figs. *eA*. From an experimental investigation of *bending of cast-iron bars*, the author concludes:

that the property of having the apparent transverse strength considerably higher than the tensile strength is not peculiar to cast iron alone. There are other tough materials in which at bending there arise apparent stresses greater than the tensile strength of the material.

As far as elasticity is concerned, cast iron shows a very irregular behavior, due probably to irregular cooling when being cast. This irregularity of behavior obscures the experimental data to such an extent that reliable conclusions can be obtained only in rare cases, especially if the span and load have been small.

Coefficients of elasticity obtained from tests with specially cast test pieces must not be applied to the design of cast-iron structures. Stresses taking place in bent bars carrying less than safe load differ from stresses calculated in the usual manner, but are by no means in the same ratio to them as tensile strength is to apparent transverse strength.

It is therefore unadvisable to accept as safe loads for cast-iron bars under flexure values which are higher than those which would be considered safe tensile stresses. The investigation of cast-iron structural parts by breaking tests is misleading; instead, elongation measurements ought to be made whenever possible, and the stresses calculated from them with a very carefully selected value of the modulus of elasticity.

The article contains full data of the tests made by the author.

Ispytanie na Yugo-Zapadnykh dorogakh babbita 83% svintza i 17% surmy (Tests on the Southwestern Railroads, Russia, of babbit metal consisting of 83% lead and 17% antimony), P. Yanushevski. *Bulletin of the Permanent Committee of the Conferences of Representatives of Russian Railroads,* February 1912. 6 p. *e.* The *babbit metal* generally used on the Russian Southwestern Railroads is made of 23% tin, 3% gunmetal, 24% antimony, 50% lead. Extensive tests were made with both the usual babbit metal, and the new one consisting of 83% lead and 17% antimony, and the following has been found:

	Specific Gravity	Hardness	Toughness	Strength
Usual babbit......................	8	23.00	18.1	34
New babbit........................	10	20.	17.5	31

The wear of bearings was found to be practically the same with both metals, but the *new babbit is more than twice as cheap* as the former.

Thermodynamics

Der Wärmeübergang von heisser Luft an Rohrwandungen. Dr.-Ing. H. Gröber. *Zeits. des Vereines deutscher Ingenieure,* March 16, 1912. 5 pp., 8 figs. *eA.* Data of an experimental investigation, made in the Laboratory of the Technical High School of Munich, on the *flow of hot air in pipes,* and in particular on the *influence of the temperature of the pipe walls and air on the transmission of heat.*

Coefficient of heat transmission and length of pipe. The coefficient α of heat transmission which was found to be very high at the beginning of the pipe, sank very rapidly as the distance from the beginning increased, and approached a minimum at the end of the pipe (this relation was formerly proved theoretically by Nusselt).

Coefficient of heat transmission and temperature of the walls of the pipe and air. By slightly varying Nusselt's theoretical formula, the author obtains the following equation for the coefficient of heat transmission:

$$\alpha = \left[15{,}90 \frac{273^{2m-1}}{d^{1-m}} \rho_o^m \, c_p^m \, \lambda^{1-m} \, w^m \right] T_w \, T_L^{-2m} = C \, T_w \, T_L^{2m}$$

where λ is the heat conductivity of air. By substituting experimentally obtained values for α from a table given in the article, the author finds, that if α is expressed as an exponential function of T_w, or temperature of the pipe wall, and T_L, or temperature of the air, the exponents of these temperatures do not remain constant, but vary with the temperatures, and from 0 to plus 100 deg. cent. are approximately what Nusselt found, but differ considerably from his values at higher temperatures. The author believes that even at temperatures as low as 200 to 300 deg. cent. the radiation of heat of the gas is large enough to affect the law of heat transmission.

The second part of the article deals with the problem of *radiation of heat of gases.* The author begins by deriving a general formula which permits to calculate the radiation from one area through another opposite it, and through the intervening layer of air. This equation is then applied to the case of the flow of air in a pipe, and the heat transmitted by radiation is calculated as part of the total heat transmitted. When the heat is transmitted by radiation alone, this radiation formula may be applied; when it is transmitted only by radiation and conduction, the Nusselt equation should be applied, and a special law has yet to be formulated to include cases lying between these two extremes.

Miscellaneous

Maschinenwirtshaft in Hüttenwerken, Dr. H. Hoffman. *Zeits. des Vereines deutscher Ingenieure*, March 16, 23 and 30, 1912. 16 pp., 41 figs. *d.* Discussion of the modern development of machinery in metallurgical works plants, such as power stations, gas engines, blowers, rolls, etc., from the point of view of economic efficiency and reliability, with many illustrations of modern types of engines and plants.

Supplementary references:

Tosi, Steam Turbine (Foreign Review, May, 1912, p. 802) Cp. *Engineering* (London), April 26, 1912, p. 555.

GAS POWER SECTION

PRELIMINARY REPORT OF LITERATURE COMMITTEE

(XVIII)

ARTICLES IN PERIODICALS[1]

Abgase von Gasmaschinen, Ausnutzung. *Stahl und Eisen*, April 4, 1912. 2/3 p., 2 figs. *p.*

A mention of an appliance for utilizing the exhaust heat from gas or oil engines.

Betrieb von Generatoröfen, Der, R. Geipert. *Journal für Gasbeleuchtung*, March 2 and 9, 1912. 10 pp., 7 figs., 3 tables.

The operation of gas plants.

Combustibles médiocres dans les mines du district de Dortmund, Utilisation des, Dobbelstein. *Notes Technique de Comité Central des Houilleres de France*, April 1, 1912. 7 pp., 3 figs., 12 tables.

Utilization of exhaust gases from mines in the district of Dortmund.

Diesel Engine, A New. *The Engineer* (London), April 19, 1912. 2 pp., 6 figs. *dmpC.*

General description with some changes in details of engine built by Franco Tosi, of Legnano, Italy.

Diesel Engine Design, Some Aspects of, D. M. Shannon. *Engineering*, May 3, 1912. 5½ pp., 3 figs., 3 tables. *dm.*

Paper before the Institution of Engineers and Shipbuilders of Scotland, April 23, 1912.

Diesel Engine Formula, A New, P. A. Holliday. *The Engineer* (London), April 5, 1912. ½ p., 1 curve. *mpA.*

Formula for bore, stroke and revolutions per minute when required horsepower is given.

Kerpely Gaserzeugers, Über eine neue Bauart des, H. Hermanns. *Dinglers polytechnisches Journal*, March 9, 1912. 2 pp., 1 fig., 4 tables.

Describes a new type of Kerpely gas producer.

Moteurs à combustion sans soupape, Quelques, G. Richard. *Revue de mécanique*, March 31, 1912. 32 pp., 100 figs., 3 tables, 6 curves. *A.*

Valveless motors showing various types.

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[1] Opinions expressed are those of the reviewer, not of the Society. Articles are classified as *c* comparative; *d* descriptive; *e* experimental; *h* historical; *m* mathematical; *p* practical. A rating is occasionally given by the reviewer, as *A*, *B*, *C*. The first installment was given in The Journal for May 1910.

Rohoelmotore. Neuere, Ch. Pohlmann. *Journal für Gasbeleuchtung*, March 16 and 30, 1912. 8 pp., 24 figs.

New types of crude oil motor.

Turbine, The Gas, Norman Davey. *The Engineer* (London), April 5, 12, 26, 1912. 6½ pp., 8 figs., 1 table, 4 curves. *dmpA.*

Describes, with formulæ and curves, the steam and air turbine and the rotary air compressors.

Torfgasanlage, Bericht über die Untersuchung einer, H. Baer. *Zeit. des Vereines deutscher Ingenieure*, April 6, 1912. 4 pp., 3 figs, 1 table, 9 curves.

Report of an investigation of a peat gas installation.

Zentralgeneratorgasanlangen in den Wiener städtischen Gaswerken, Die, K. Marischka. *Journal für Gasbeleuchtung*, April 13, 1912. 6 pp., 5 figs.

Gas plant of the city of Vienna, Austria.

REPORTS OF MEETINGS

SAN FRANCISCO MEETING, APRIL 3

A meeting of the Society was held in San Francisco on April 3, at which the paper by R. E. Cranston on The Design and Mechanical Features of the California Gold Dredge was presented and discussed. Those who participated in the discussion were R. H. Postlethwaite, member of the Institution of Electrical Engineers, London, and of the American Institute of Mining Engineers; J. W. Plant, Mem. Am. Soc. M. E., engineer with the Edgar Allen American Manganese Steel Company, San Francisco; W. C. Knox; Thomas Morrin, Mem. Am. Soc. M. E., consulting engineer, San Francisco; and the author.

NEW YORK MEETING, MAY 14

The topic of Commercial Dictating Machines was discussed at a meeting of the Society in New York on May 14, in the Engineering Societies Building. The opening remarks were made by A. J. McFaul of the Allen Advertising Company of New York, who has made a study of the various methods of recording and reproducing speech, with particular reference to the increase of practical efficiency in handling dictation in offices. He was followed by C. K. Fankhauser of the American Telegraphone Company, Springfield, Mass., Otto Brushaber of the Dictaphone Company, New York, S. H. Bunnell, Mem. Am. Soc. M. E., consulting engineer and efficiency expert, New York, Q. Diepenbrock, T. C. Martin, Jr., W. W. Macon, Assoc. Am. Soc. M E., engineering editor of the Iron Age, New York, George A. Orrok, Mem. Am. Soc. M. E., New York Edison Company, New York, and H. F. J. Porter, Mem. Am. Soc. M. E., consulting engineer, New York. Demonstrations of the various machines on the market followed the meeting.

Previous to the meeting a number of the New York members gathered at dinner at the Engineers Club, thus introducing an agreeable social feature.

BOSTON MEETING, MAY 17

At a meeting of the Society in Boston on May 17, two papers were presented: Progress in Development of a New Type of Centrifugal Pump and Blower, especially for Steam Turbine Drive, by C. V. Kerr, Mem. Am. Soc. M. E., and A. L. Schaller, Jun. Am. Soc. M. E., of McEwen Brothers, Wellsville, N. Y.; and Increase of Bore of High-Speed Wheels by Centrifugal Stresses, by Sanford A. Moss, Mem. Am. Soc M E, of the Turbine Research Department of the General Electric Company, West Lynn, Mass. Both of the papers were fully illustrated with lantern slides. The papers were discussed by J. B. Sando, followed by a more informal discussion in which a number participated.

STUDENT BRANCHES

COLUMBIA UNIVERSITY

Mechanical Engineering in the Steel Industry, by Carl Meissner, was presented at the April 25 meeting of the Student Branch of Columbia University.

CORNELL UNIVERSITY

At the May 1 meeting of the Sibley College Student Branch, William H. Boehm, Cornell 1892, of the Fidelity and Casualty Company of New York, read a paper on Boiler Explosions which was illustrated by lantern slides.

LEHIGH UNIVERSITY

The Student Branch of Lehigh Univeristy held a meeting on April 11 at which the following papers were presented: Breakage of Steel Rails, by H. S. Fowler. The possible cause for the many rail breakages in winter was attributed to piping, together with possible changes of crystalline structure at extremely low temperatures; also improper counterbalancing of the locomotive producing excessive pressure on the rails during high speed. G. S. Chiles discussed the paper. R. V. Parker's paper on Future of the Steam Turbine discussed all the important types of reaction and impulse turbines and the services required of them. A paper on Variable Speed Transmission on Motor Trucks, by J. H. Sheppard, outlined the Manly system which may make possible the elimination of a large bulk of gear transmission and other controlling devices when used on motor trucks, gun mounts, etc. This was discussed by Prof. H. S. Howarth.

MASSACHUSTEES INSTITUTE OF TECHNOLOGY

At the May 8 meeting of the Mechanical Engineering Society of the Massachussetts Institute of Technology, Charles M. Mumford delivered an illustrated lecture on The Development of a Fine Goods Cotton Mill. The illustrations showed floor plans of the mill, arrangement of machinery and views of the buildings. Professor Haven and Mr. Obrien discussed the paper.

POLYTECHNIC INSTITUTE OF BROOKLYN

On April 27 the Polytechnic Institute of Brooklyn Student Branch held its first annual dinner, at which Dr. J. B. Chittenden, head of the department of mathematics, was toastmaster. The speakers of the evening were F. R. Low, Assoc. Am. Soc. M. E., President Atkinson, G. A. Orrok, Mem. Am. Soc. M. E., Chas. E. Potts, and Prof. W. D. Ennis, Mem. Am. Soc. M. E.

Jas. W. Nelson, Assoc. Am. Soc. M. E., gave a lecture on The Eight Years' Occupation of the Canal Zone by the American People Since May 1904, at the May 4 meeting. A general discussion followed.

STEVENS INSTITUTE OF TECHNOLOGY

At the May 7 meeting of the Stevens Engineering Society, the treasurer's final report for the season was read and accepted. The election of officers for the season 1912-1913 resulted as follows: chairman, John Henry VanderVeer; vice-chairman, Carleton Wandel; secretary, Jerome Strauss; treasurer, Jacob H. Bräutigam.

UNIVERSITY OF CALIFORNIA

At a meeting of the Student Branch of the University of California held on February 20, a paper on Pyrometers, by J. P. Zipf, was presented. On March 3 the Branch was addressed by E. A. Slater on Power Plants of Steam Ships. At the March 19 meeting, Prof. J. N. Le Conte, Mem. Am. Soc. M. E., spoke informally on the object and work of the Branch and delivered a lecture on the Auxiliary Fire Protection System of San Francisco. On April 3, W. P. Custer read a paper on Centrifugal Pumps. At the April 16 meeting the following officers were elected for the fall term: chairman, G. M. Simonson; vice-chairman, J. F. Ball; secretary, G. H. Hagar; treasurer, M. E. Page. A paper on Mallet Compound Engines was read by J. B. Wells, Jun. Am. Soc. M. E.

UNIVERSITY OF CINCINNATI

The University of Cincinnati Student Branch held its regular monthly meeting on April 23 in the club room of the New Engineering Building at which reviews of the current numbers of engineering magazines were presented by the student members.

UNIVERSITY OF ILLINOIS

On April 26 the University of Illinois Student Branch held its regular bi-monthly meeting. The subject of the evening was Steam Turbines. T. E. Maury presented a paper on the DeLaval Turbine and A. T. Weydell gave an illustrated talk on the Curtis Machine. A general discussion followed.

UNIVERSITY OF KANSAS

The Southern Power Company, by Earl Rush, and The Mechanical Handling of Freight, by R. H. Forney, were presented at the April 11 meeting of the University of Kansas Student Branch.

On April 18, Prof. P. F. Walker, Mem. Am. Soc. M. E., delivered a lecture on Ideals for Engineers, and on April 25, his lecture on The Design and Manufacture of Large Ships was illustrated by lantern slides which showed the growth of the modern ship and internal construction of steel ships.

UNIVERSITY OF MISSOURI

At the April 15 meeting of the University of Missouri Student Branch a debate was held on the following subject: Resolved, That in an oil field district it is better to use the oil in internal-combustion engines than to burn it under steam boilers, for a plant of about 2000 kw. capacity. P. A. Tanner and F. I. Kemp were on the affirmative side and A. E. Heptonstall and R. M. James on the negative. The affirmative side won the debate.

NECROLOGY

ERNEST S. BOWEN

Ernest S. Bowen was born at Levanna, N. Y., May 28, 1858, and died at Geneva, N. Y., April 27, 1912. At an early age he went to work for the J. A. Spencer Iron Works, Union Springs, N. Y., where he received his first training and practical experience in mechanics. Realizing the advantage of a technical education, he entered Cornell University and worked his way through, graduating in the class of 1890. Immediately after graduation he entered the employ of the McIntosh Seymour Engine Company, manufacturers of high-speed engines, Auburn, N. Y., of which he soon became assistant superintendent. In 1895 he embarked in business for himself, forming a partnership with Walter L. Fay, also of Auburn, for the manufacture of bicycle parts. After five years they sold out, but re-formed a partnership for the manufacture of marine engines under the name of Fay & Bowen. As this business grew they added to it the manufacture of motor boats, which necessitated their moving to a location with a water front. They were attracted to Geneva and in 1904 the business was incorporated under its present name of the Fay & Bowen Engine Company and it has steadily grown until it is one of the leading concerns of its kind in the country.

JAMES P. S. LAWRANCE

James P. S. Lawrance was born in Philadelphia in 1852 and attended the Episcopal Academy in that city. He was matriculated at the Lehigh University and graduated in 1873 with the degree of M. E. He served about one year under instruction in the machine shop of John Roach & Sons, Chester, Pa., to qualify for the Engineering Corps of the Navy, which service he entered as second assistant engineer in March 1875. He made a three years' cruise on the Asiatic Station and another on the Pacific Station, also a six months' cruise on the North Atlantic Station in a sea-going monitor. In April 1883 he was ordered to duty in the office of Naval Intelligence in the Bureau of Navigation, Navy Department, and in June 1883 was

commissioned a past assistant engineer in the United States Navy. Subsequently Captain Lawrance served at the Norfolk and the Washington Navy Yards; the Homestead Steel Works and the Thurlow Steel Works. He took part in the "battles" of Cardinas and Manzanello during the war with Spain and made voyages through the Straits of Magellan, the Suez Canal, up the Amazon River about 2000 miles, and around the world. He was promoted in the regular course up to the rank of chief engineer in the Navy and by virtue of the act of Congress approved March 3, 1899, was transferred into the line of the Navy and promoted to the rank of commander. At his own request his name was transferred to the retired list June 30, 1905, which promotion carried with it the rank of captain. He died January 16, 1912.

Captain Lawrance was a member of the American Association for the Advancement of Science.

I. CHESTER G. WILKINS

I. Chester G. Wilkins was born in Whitehall, N. Y., September 8, 1871. He received his early education in the public schools of Whitehall and in 1893 was graduated from Cornell University with the degree of M. E. His first work was in the railroad shops of Whitehall, and in August 1894 he went to New York entering the employ of Evans, Almirall & Company, heating and ventilating engineers and contractors, with whom he remained until May 1895. He then obtained a position with C. O. Brown, consulting engineer, Brooklyn, N. Y., and from March 1896 to May 1899 designed heating and ventilating apparatus for public school buildings. He went to Baltimore, Md., having secured a position with Henry Adams, consulting engineer, and two years later returned to New York to fill a position with Thompson-Starrett Company, with which concern he remained till his death, April 20, 1912. His work during this period consisted in the design, specification and general supervision of installations of mechanical equipment for such buildings as James McCreery & Company's store at 9 West 34th Street, New York; the Crescent Athletic Club, Brooklyn, the Adelphia Theater, Philadelphia; the Title Guarantee & Trust Company's bank and office building, Brooklyn; the New York Steam Company's boiler house; and John D. Rockefeller's residence, Pocantico Hills, N. Y.

GEORGE H. SULZER

George H. Sulzer, chief designer and manager of the centrifugal pump department of the Worthington Hydraulic Works, Harrison, N. J., died in New York April 20, 1912. Mr. Sulzer was born in Winterthur, Switzerland, October 21, 1877. He received his early education at the public schools and industrial college of Zurich. His professional training was obtained at the Polytechnic Institute of the same town, where he received his diploma in 1902. For several years after his graduation he was assistant in the department for centrifugal pumps and turbines at the Polytechnic Institute. In 1903 he sailed for America and found employment with R. D. Wood & Company, Camden, N. J., and later on the engineering staff of the Buffalo Forge Company. In 1906 he was engaged by the Henry Worthington Company to take charge of the design of centrifugal pumps, which had always been his specialty. He had an unusually intimate understanding of the theory and construction of rotating machinery, particularly of the newer types of pumps, and his services were most valuable in the solution of special problems, even though he was often handicapped by the prevailing commercial tendencies and conditions. He was a member of the Newark branch of the Deutscher Technischer Verein, being its president for two terms. He was also a member of the Vereinigung der Schweizerischen Techniker.

EMPLOYMENT BULLETIN

The Society considers it a special obligation and pleasant duty to be the medium of securing better positions for its members. The Secretary gives this his personal attention and is most anxious to receive requests both for positions and for men available. Notices are not repeated except upon special request. Copy for the Bulletin must be in hand before the 12th of the month. The list of men available is made up of members of the Society, and these are on file in the Society office, together with names of other good men not members of the Society, who are capable of filling responsible positions. Information will be sent upon application.

POSITIONS AVAILABLE

0166 Wanted for New York City and vicinity, experienced salesman for iron castings, both rough and machined; to have established trade and be a man of standing and ability. Apply through Am. Soc. M. E.

0167 Salesman for boiler-plant machinery, must have experience. State references and salary expected.

0168 Assistant professor of mechanical engineering in college in middle west; to teach general mechanical engineering; line of subjects including drawing, descriptive geometry, mechanical laboratory, turbines, gas engines, power-plant design and similar subjects. Salary $1200.

0169 Any member proposing a trip to Cuba in the immediate future may secure information regarding representation in Havana of a New York concern by applying to the Secretary. Remuneration for this special service in excess of $1000 if representation is successful.

0170 Iowa concern desires manager for engineering department; good executive, capable of preparing heating plans and specifications or superintending the making of same with technical education and thoroughly reliable in every way. Apply through Am. Soc. M. E.

0171 Superintendent for factory employing about 300 men, manufacturing heating apparatus and steam specialties. Location middle west. Apply through Am. Soc. M. E.

0172 Engineer salesman for concern in New York; must understand fans, exhausters, etc.

MEN AVAILABLE

421 Member has held important positions in the manufacture of injectors, lubricators and brass steam specialties; qualified to fill a position as superintendent of works manufacturing these lines. Inventor of several improvements in jet apparatus. Some sales experience.

422 Member, 12 years' broad experience in all branches of industrial construction would like to secure position with large industrial plant as mechanical engineer or engineer in charge of construction, or with consulting engineer who

is in need of man to relieve him of responsibility and see large work through from rough sketches to operation. Best of references and testimonials. Salary $4200 to $5000 according to location. Can arrange interview in New York or vicinity. Available in July.

423 Junior member, 27, desires to change his connections. Five years' experience in steel business covering, engineering, production, costs, and selling; position in any line where hard and conscientious work will be appreciated.

424 Member, Cornell graduate, experience, ten years machine shop, six years drafting and other engineering work, five years teaching in all branches of mechanical engineering and almost all subjects usually given in that course. Capacity for organizing. Now in charge of machine design and construction. desires change.

425 Technical graduate, 12 years' experience foundry and machine shop manufacturing specialties; in charge of drafting construction and assistant executive, also some experience as salesman; past five years superintendent manufacturing plant. Some money to invest if desirable.

426 Mechanical engineer, seven years' experience in the design, construction and operation of portland cement plants, familiar with wet and dry processes; desires position with manufacturer of portland cement, would be especially valuable to concern desiring to modernize plant or to build. Now employed in a position similar to the one desired. Graduate of Cornell University, Jun. Am. Soc. M. E. Age 32, married.

427 Motor-truck engineer and designer open for proposition with progressive commercial car firm as transportation expert, efficiency man and data collector; competent to investigate, analyze and report upon prospects for truck sales in any industry, or to act in educational capacity among merchants in cities where few trucks are in use. Seven years' continuous experience in commercial car business, in drawing room, factory superintendent, publicity and editorial work.

428 Wanted position as mechanical engineer for a manufacturing plant employing about 1500 to 2000 men; can give first class references as to reliability and capability; now employed as designer of machinery but desires to make a change. Salary $3000 to $4000.

429 Junior member, technical graduate, marine and mechanical engineering, one year in night law school; age 27. Experience as factory foreman and assistant superintendent; assistant engineer and chief draftsman with a reinforced concrete steel company. Assistant engineer and superintendent of construction on factory and mill construction work. Would like to become permanently located with manufacturing or industrial concern either in technical or business way with view of working up in the business.

430 Technical graduate, would like position with engineering department of concern manufacturing steam or gas engines or consulting engineer having steam or gas engine work. Good experience in locomotive repair shops.

431 Junior member, age 25, graduate of Massachusetts Institute of Technology, desires position offering advancement, has had over two years' experience, teaching and in construction work. At present employed as assistant mechanical engineer for large hardware concern and also in cost department.

432 Position of assistant manager, chief engineer or superintendent of an industrial or power plant wanted by Junior member, having experience in engineering and experimental department of railroad, operating, erecting and laying out power plants, and general machinery in industrial works and all duties under jurisdiction of master mechanic of large chemical works.

433 Junior member, A. B. Yale, M. E. Columbia, would like to become associated with engineer or firm making specialty of design and construction of industrial plants. Experience in this line as superintendent of construction, assistant to works manager, etc.

434 Production engineer with long experience in the reduction of costs and in the introduction and operation of scientific management, wishes to get into communication with university or technical college desiring a professor in these lines.

435 Position desired with progressive manufacturing concern as executive mechanical engineer with opportunity to make savings in non-productive departments or design new additions; graduate Massachusetts Institute of Technology, American, 20 years' experience in construction, design and operation power plants and mills in various parts of United States and Canada.

436 Junior member, age 27, married, experienced in power plant erection and operation, including refrigeration experience, now employed, but desires to locate with a reliable concern with opportunity to advance. Can furnish the best of references of character, ability, etc.

437 Junior, technical education, three years' experience in gas and electric business, and two years in charge of engineering laboratory; desires change of position. Available July 1.

438 Designing engineer, nine years' experience, thoroughly familiar with design of cranes and hoisting equipment; at present employed as assistant chief draftsman by large crane builder; desires position of greater responsibility; such as complete charge of designing department of small growing firm. Location west or middle west preferred.

439 Position desired with a manufacturing company as superintendent of maintenance or industrial engineer. Eleven years' practical and technical experience in designing and constructing of machinery, jigs, tools, safety appliances, transmission, steel mill, and reinforced concrete buildings; equipments, heating and ventilating, estimating costs, writing specifications and contracts, drafting and supervision. Is accustomed to handling men. Can furnish references. Age 29, married. Location middle west.

440 Member with broad experience in construction and operation of power plants, shop experience and capable of handling any problem in design and construction that is met in water or light plants. At present employed as chief engineer of power for large mining company. Would prefer position in south or west or in Spanish or English speaking foreign country.

441 Works manager, long experience on light manufacturing, involving interchangeable parts. Competent to organize all departments of manufacturing plant along modern lines.

442 Technical graduate. Junior member. Ten years' experience in the shop and drafting room on automatic machinery, specializing on jigs and fixtures for

the manufacture of duplicate parts. Now superintendent of small manufacturing concern, desires position in larger growing organization as assistant to manager or superintendent.

443 Mechanical engineer and draftsman. Best of references.

444 Position as manager desired, by technical graduate ; experience as machinist, draftsman, production and industrial engineering, installation, shop and cost systems, rearranging, equipping and layout of plants and electrical installations. Age 32. Now superintendent of factory employing 150 to 200 men.

445 Mechanical engineer, wide experience designing, building and installing machinery. Familiar with hoisting, conveying and electrical machinery, bakery and flour handling, automobile building and special machinery. Have always "made good." Desires position where varied experience will be valuable, either in engineering office or manufacturing plant. Age 40. Accustomed to executive positions.

ACCESSIONS TO THE LIBRARY

With Comments by the Librarian

This list includes only accessions to the library of this Society. Lists of accessions to the libraries of the A. I. E. E. and A. I. M. E. can be secured on request from Calvin W. Rice, Secretary Am. Soc. M. E.

American Institute of Architects. Proceedings 45th annual convention, 1911. *Washington, 1912.* Gift of the institute.

American Railway Bridge and Building Association. Proceedings of the 21st annual convention. *Chicago, 1911.* Gift of the association.

Anuario Estadistico de la Republica Oriental del Uruguay, 1907-1908. Vol. 2, Pt. 1. *Montevideo, 1911.* Gift of Republica Oriental del Uruguay.

Applied Methods of Scientific Management, F. A. Parkhurst. *New York, Wiley & Sons, 1912.*

This work is an amplification of the author's articles in Industrial Engineering and deals, not with the theoretical side of the subject, but with the details of its practical application. The work is well illustrated, many forms being given.

Ein Besuch im Deutschen Museum Abteilung II, Zweibrückenstrasse, K. Matschoss. Sonderabdrick aus der Zeitschrift des Vereins Deutscher Ingenieure, 1909. Gift of Wm. Paul Gerhard.

Centrifugal Pumping Machinery. The theory and practice of centrifugal and turbine pumps, C. G. de Laval. *New York, McGraw-Hill Book Co., 1912.*

Based on practical experience in the design, construction and installation of pumping machinery of centrifugal type, and confines itself to material which has been used in the actual practice of the author with Henry R. Worthington.

Coal Smoke Abatement Society. Papers read before the Smoke Abatement Conferences March 26, 27, 28, 1912. *Westminster, 1912.* Gift of the society.

Connecticut Bureau of Labor Statistics. Bulletin, 1911. *Hartford, 1911.*

Die Dampfkessel nebst ihren Zubehörteilen und Hilfseinrichtungen, R. Spalckhaver und Fr. Schneiders. *Berlin, 1911.*

Deutsches Museum Lebensbeschreibungen und Urkunden, George von Reichenbach, Walther v. Dyck. *München, 1912.* Gift of the author.

Deutsches Museum von Meisterwerken der Naturwissenschaft und Technik. Führer durch die Sammlungen. *Leipzig.* Gift of Wm. Paul Gerhard.

Driver-Harris Wire Company. Properties of Round and Fattened "Nichrome" Wire. *1911.* Gift of the company.

Earning Power of Chemistry, Arthur D. Little. Professional Paper no. 5. Contributions to Engineering Chemistry by members of the staff of Arthur D. Little, Inc. *Boston, 1911.* Gift of Arthur D. Little, Inc.

EINRICHTUNG UND BETRIEB EINES GASWERKES, A. Schäfer. *München-Berlin, 1910.*

ELECTRIFICATION OF RAILWAYS, George Westinghouse. Gift of Westinghouse Electric & Manufacturing Co.

ELEMENTS OF STATISTICAL METHOD, W. I. King. *New York, Macmillan Co., 1912.*

Treats of the technical processes involved in the work of the statistician in the collection, compilation and interpretation of statistical data. The first work of the kind.

DER FABRIKBETRIEB, Albert Ballewski and C. M. Lewis. Ed. 3. *Berlin, 1912.*

FORSCHERARBEITEN AUS DEM GEBIETE DES EISENBETONS. Nos. 1-10, 12-17, 19. *Wien-Berlin, 1904-1912.*

HANDBUCH DER MATERIALIENKUNDE FÜR DEN MASCHINENBAU, A. Martens. Pt. 2. Die technisch wichtigen Eigenschaften der Metalle und Legierungen, E. Heyn. *Berlin, 1912.*

INTRODUCTION TO ANALYTICAL MECHANICS, Alexander Ziwet and Peter Field. *New York, Macmillan Co., 1912.*

A text book for junior and senior students based largely on the senior author's Theoretical Mechanics. The authors are professors in the University of Michigan.

KRAN UND TRANSPORTANLAGEN FÜR HÜTTEN, HAFEN, WERFT UND WERKSTATT BETRIEBE, C. Michenfelder. *Berlin, 1912.* Gift of Hunt Memorial Fund.

LABORATORY MANUAL FOR THE USE OF STUDENTS IN TESTING MATERIALS OF CONSTRUCTION, L. A. Waterbury. *New York, Wiley & Sons, 1912.*

Intended as a manual for use in schools where all testing is given in one course.

LEHRBUCH DER EISEN UND STAHLGIESSEREI, Bernhard Osann. *Leipzig, 1912.*

LOUISVILLE WATER COMPANY. Annual Report, 54th. *Louisvile, 1911.* Gift of Theo. A. Leisen.

LE MECHANICHE, Guido Uvalde. *1581.*

DIE METALL UND EISENGIESSEREI MIT BESONDERER BERÜCKSICHTIGUNG DER LEGIERUNGEN UND GATTIERUNGEN FÜR DEN MASCHINENBAU, Hugo Wachenfeld. *Halle a. S., 1911.*

MILWAUKEE BUREAU OF ECONOMY AND EFFICIENCY. Bulletin, 17, 19. *Milwaukee, 1912.*

MUNICIPAL ENGINEERS OF THE CITY OF NEW YORK. Constitution, By-Laws, List of Members and Annual Report, 1911. *New York, 1911.*

MUNICIPAL ENGINEERS OF THE CITY OF NEW YORK. Proceedings, 1911. *New York, 1911.* Gift of Municipal Engineers of the City of New York.

NEW YORK CENTRAL AND HUDSON RIVER RAILROAD COMPANY. Annual Report of the Board of Directors to the Stockholders, 43d, 1911. *New York, 1911.* Gift of the company.

NEW YORK CITY BOARD OF WATER SUPPLY. Contract 72, 112, 113, 114. *1912.* Gift of Board of Water Supply.

ÖLMOTOREN IN VIERTAKT-UND ZWEITAKTBAUART, H. Haeder. Vols. 1-2. *Wiesbaden, 1912.*

ORGANISATION ET DIRECTION DES USINES, André Mayer. *Paris, 1911.*

POLHEM, CHRISTOPHER. MINNESSKRIFT UTGIFVEN AF SVENSKA TEKNOLOGFÖRENINGEN. *Stockholm, 1911.* Gift of Svenska Teknologföreningen.

PRACTICAL TREATISE ON LOCOMOTIVE ENGINES UPON RAILWAYS, F. M. G. de Pambour. *Philadelphia, 1836.*

The first book on the locomotive printed in America.

REALITÄTEN, ABSTRAKTIONEN, FINGIERUNGEN UND FIKTIONEN IN DER THEORETISCHEN MECHANIK VON O. E. WESTIN. *Stockholm, 1911.* Gift of Svenska Teknologföreningen.

SCIENTIFIC AMERICAN CYCLOPEDIA OF FORMULAS, A. A. Hopkins. *New York, 1911.*

SPRINGFIELD, MASS., BOARD OF WATER COMMISSIONERS. Annual Report, 38th, 1911. *Springfield, 1912.* Gift of the board.

THE TEACHING OF PHYSICS FOR PURPOSES OF GENERAL EDUCATION, C. R. Mann. *New York, Macmillan Co., 1912.*

Edited by President Butler of Columbia. The work is not, as might be supposed, an outline of courses or laboratory manual, but a discussion of the principles underlying the teaching for purposes of general culture. There are quite extensive bibliographies appended to several of the chapters, and a satisfactory index.

WÄRMETHEORIE UND IHRE BEZIEHUNGEN ZUR TECHNIK UND PHYSIK, Wegner von Dallwitz. *Berlin, 1912.*

UBER WÄRMEÜBERGANG AUF RUHIGE ODER BEWEGTE LUFT SOWIE LÜFTUNG UND KÜHLUNG ELEKTRISCHER MASCHINEN, Ludwig Binder. *Halle a. S., 1911.*

WEBB'S ACADEMY AND HOME FOR SHIPBUILDERS. Annual Report, 1911. *New York, 1911.* Gift of the academy.

UNITED ENGINEERING SOCIETY

GUIDE TO THE TECHNOLOGICAL MUSEUM, Sydney, N. S. W. *Sydney, 1910.* Gift of the museum.

ILLUMINATION OF PEOPLE'S GAS BUILDING, CHICAGO. A paper by Chas. A. Luther, read before the Illinois Gas Association March 20, 1912. Gift of People's Gas Light & Coke Co.

KAISERLICHE MARINE DEUTSCHE SEEWARTE. Jahresbericht über die Tätigkeit der Deutschen Seewarte. 33, 34. 1910-1911. *Hamburg, 1911-1912.* Gift of Annalen der Hydrographie.

PRESENT STATE OF THE EUCALYPTUS OIL INDUSTRY, Henry G. Smith. *1911.* Gift of the author.

TRUTH ABOUT MR. ROCKEFELLER AND THE MERRITTS, *F. T. Gates.* Gift of the author.

VITRIFIED BRICK PAVEMENTS FOR CITY STREETS AND COUNTRY HIGHWAYS. Gift of National Paving Brick Manufacturers' Association.

EXCHANGES

AMERICAN SOCIETY OF CIVIL ENGINEERS. Transactions, vol. 74. *New York, 1911.*

CANADIAN SOCIETY OF CIVIL ENGINEERS. Charter, By-Laws and List of Members, 1912. *Montreal, 1912.*

INSTITUTION OF CIVIL ENGINEERS. Minutes of Proceedings, vol. 187. *London. 1912.*

SOCIETY OF NAVAL ARCHITECTS AND MARINE ENGINEERS. Transactions, vol. 19, 1911. *New York, 1911.*

TRADE CATALOGUES

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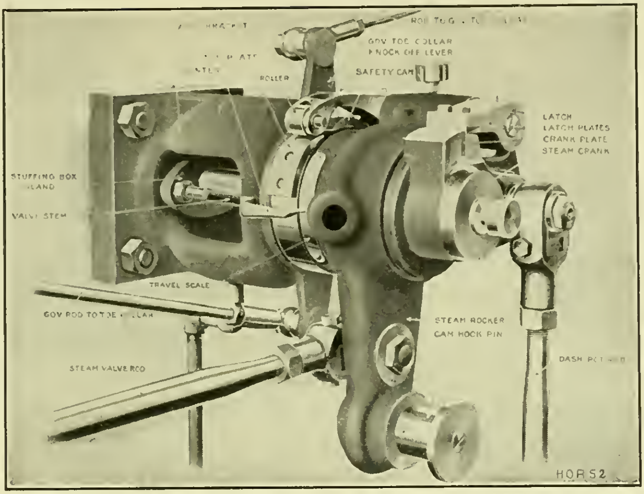

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Telephone: 6097 Franklin

Heat and Cold Insulating Materials. Headquarters for 85% Magnesia Asbestos and Brine Pipe Coverings, Asbestos Products, etc.

VALVES

THE KENNEDY VALVE MANUFACTURING CO.

ELMIRA, N. Y. — 57 Beekman St., NEW YORK

Manufacturers of Valves for various purposes and pressures; Hydrants; Indicator Valves for Automatic Sprinkler Equipment.

VALVES BLOW-OFF VALVES FIRE HYDRANTS

THE LUDLOW VALVE MFG. CO.

TROY, N. Y.

Manufacturers of genuine Ludlow Gate Valves for all purposes. Special Blow-off Valves. Check Valves. Foot Valves. Sluice Gates. Indicator Posts. Fire Hydrants.

VALVES INJECTORS LUBRICATORS ETC.

THE LUNKENHEIMER COMPANY

CINCINNATI, OHIO

Manufacturers of high-grade engineering specialties, comprising Brass and Iron Valves Whistles, Cocks, Gauges, Injectors, Lubricators, Oil Pumps, Oil and Grease Cups, etc., adapted to the requirements of all classes of machinery.

VALVES

MONARCH VALVE & MANUFACTURING CO.

39 Cortlandt St., NEW YORK — SPRINGFIELD, MASS.

Manufacturers of Bronze and Iron Bodied Valves for various pressures and purposes.

STEAM TRAPS

MOREHEAD MANUFACTURING CO.

DETROIT, MICH.

Return, Non-Return Vacuum and Condenser Steam Traps. The Morehead Tilting Steam Trap is the original design of *tilting* trap, having been on the market for a quarter of a century. For reliable and satisfactory service this type of trap recommends itself. Illustrated descriptive catalog sent on request.

PUMPS AND HYDRAULIC TURBINES

POWER TRANSMISSION

FRICTION CLUTCHES

THE CARLYLE JOHNSON MACHINE CO.

MANCHESTER, CONN.

Send for our Catalog, and Clutch Booklet entitled "Clutches for Use in Machine Building." The information set forth therein will be of interest to any Builder or Designer of Machinery.

POWER TRANSMISSION ELEVATORS CONVEYORS

DODGE MANUFACTURING CO.

MISHAWAKA, IND.

Manufacturers of everything for the Mechanical Transmission of Power; also Elevating and Conveying Machinery, and the "Eureka" Water Softener. Send for general catalog C–10.

POWER TRANSMISSION APPLIANCES

FALLS CLUTCH & MACHINERY CO.

CUYAHOGA FALLS, OHIO

Friction Clutch Pulleys, Couplings, Quills, Operators, Clutch Sheaves, Floor Stands, Heavy Mill Bearings, Shaft Couplings, Sheaves and Tension Carriages, Pulleys and Fly Wheels.

STEEL BELT LACING

FLEXIBLE STEEL LACING CO.

542 W. Jackson Boulevard CHICAGO, ILL.

Alligator Steel Belt Lacing. Adapted for use on leather, rubber, balata, cotton or canvas-stitched belting of any width or thickness. A perfect flexible joint and separable hinge joint that works satisfactorily with an idler.

POWER TRANSMISSION

THE HILL CLUTCH COMPANY

CLEVELAND, OHIO

Manufacturers of a complete line of Power Transmission Machinery for belt, rope or gear driving, including the well known Hill Friction Clutches and Hill Collar Oiling Bearings.

PULLEYS—PAPER FRICTION TRANSMISSION

THE ROCKWOOD MANUFACTURING CO.

INDIANAPOLIS, IND.

Rockwood Paper Frictions have proven their unquestioned superiority. You will find our booklets regarding Transmission of Power by Belts and Friction Transmission desirable additions to your engineering library.

POWER TRANSMISSION

T. B. WOOD'S SONS CO.

CHAMBERSBURG, PA.

Modern and Approved Appliances for the transmission of Power. Shafting, Couplings, Collars, Hangers, Pulleys, Belt Tighteners, Friction Clutches, Rope Driving Equipments.

PAPERS ON POWER TRANSMISSION

PAPERS FROM TRANSACTIONS OF A. S. M. E.

No. 585. Power Losses in Transmission Machinery of Central Stations: Aldrich, price \$.20; No. 808. Power Transmission by Belt: F. L. Emory, price \$.10; No. 1180. Power Transmission by Friction Drives: W. F. M. Goss, price \$.30; No. 1230. Paper on Belting: C. G. Barth, price \$.50.

HOISTING AND CONVEYING MACHINERY

ALLIANCE MACHINE CO.

ALLIANCE, OHIO

Makers of Alliance Cranes of all types; also Rolling Mill and Hydraulic Machinery, Steam Hammers, Punches and Shears, Scale Cars, Copper-Converting Machinery, etc.

CRANES
STEAM HAMMERS
PUNCHES AND SHEARS

THE BROWN HOISTING MACHINERY CO.

New York CLEVELAND, O., U. S. A. Pittsburg

Designers and manufacturers of all kinds of Hoisting Machinery, including Locomotive Cranes. Electric Travelers, I-beam Trolleys, Crabs, Winches, etc., as well as heavy Hoisting Machinery of all descriptions. Also Ferroinclave for reinforced concrete roofing.

HOISTING MACHINERY

H. W. CALDWELL & SON COMPANY

NEW YORK CHICAGO

Elevating, Conveying and Power Transmitting Machinery. Helicoid and screw conveyors, machine molded gears, pulleys, fly-wheels, rope sheaves and drives, sprocket wheels and chain, buckets, belting, shafting and bearings.

CONVEYORS
ELEVATORS
POWER TRANSMISSION

CLYDE IRON WORKS

DULUTH, MINN.

Hoisting Engines and Derricks. All sizes and types of engines.

HOISTING ENGINES AND DERRICKS

THE EASTERN MACHINERY COMPANY

NEW HAVEN, CONN.

Manufacturers of Electric and Belt Power Passenger and Freight Elevators, Hoisting Machines, Friction Winding Drums, Friction Clutches and Friction Clutch Pulleys.

ELEVATORS
FRICTION CLUTCHES
PULLEYS

THE B. F. GOODRICH CO.

AKRON, OHIO

Manufacturers of Goodrich Conveyor Belt. The Goodrich "Longlife" "Maxecon" and "Grainbelt" Conveyors will handle more tons per dollar of cost than any other belt made.

CONVEYOR BELTS

THE JEFFREY MFG. COMPANY

COLUMBUS, OHIO

Builders of Elevating, Conveying and Mining Machinery; Coal and Ashes Handling Systems for Power Plants; Screens, Crushers, Pulverizers, Car Hauls, Coal Tipples, Coal Washeries, Locomotives, Coal Cutters, Drills, etc. Complete Coal Mine Equipments.

ELEVATING
CONVEYING
MINING
MACHINERY

ELECTRICAL APPARATUS

AIR COMPRESSORS AND PNEUMATIC TOOLS

FOUNDRY EQUIPMENT

ENGINEERING MISCELLANY

CONDENSED CATALOGUES

OF

MECHANICAL EQUIPMENT

SECTION ONE (PART TWO)

Power Plant Equipment

Other sections of the Condensed Catalogues to be published in subsequent issues of The Journal during 1912 will include Hoisting, Elevating and Conveying Machinery, Industrial Railway Equipment, Power Transmission Machinery, Electrical Equipment, Metal Working Machinery, Machine Shop and Foundry Equipment, Steel and Rolling Mill Equipment, Pumping Machinery, Mining and Metallurgical Equipment, Heating and Ventilating Apparatus, Refrigerating Machinery, Air Compressors and Pneumatic Tools, Engineering Miscellany.

At the close of the year the entire collection of Condensed Catalogues will be reprinted in volume form and distributed to members without charge.

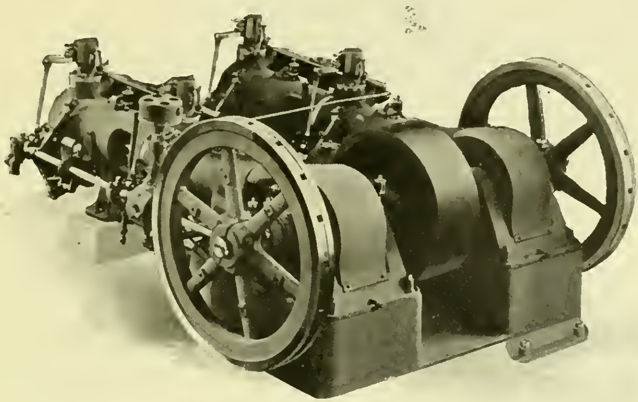
THE AMERICAN SOCIETY *of*
MECHANICAL ENGINEERS

THE ELYRIA GAS POWER CO.

ELYRIA, OHIO

GAS ENGINES

Builders of "The Little Big Engine"



FEATURES OF "THE LITTLE BIG ENGINE"

Uses Producer, Natural and City Gas, Gasoline and Distillate.

Only change necessary in change of fuel is length of connecting rod for altering compression and exchange of fuel handling devices.

Economy ranges from 10,000 to 12,000 BTU, depending on size.

All sizes with water-cooled exhaust valves; all but No. 2 have water-cooled pistons and piston rod. No water joints subject to explosion pressures.

Governs by varying lift of inlet valves. Good regulation.

Pulley or flexible coupling bolted to flywheel, either side.

Ignition make-and-break or jump spark, both for continuous service.

Our "Show-me" guarantee means much to the buyer. Get it.

Crank Shaft half of cylinder bores. Main bearings removable bushings.

Automatic Air Starting Equipment always included.

Gas Producers and Dynamos furnished. Quick delivery a feature.

Engineers can safely use for estimate figures $80 per H. P. in smallest to $60 per H.P. in largest sizes. This includes engine and anthracite producer, delivered and fully installed above foundations.

We deal with purchasers or Engineers only. We have no Agents.

APPROXIMATE RATINGS AND FLOOR SPACE

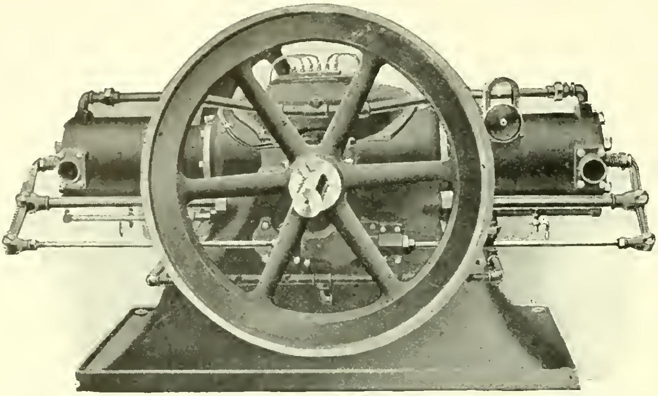
Fuel	Compression	Engine No. 2		Engine No. 3		We twin the No. 4 and No. 5 — Engine No. 4		Engine No. 5	
						When twinned, double rating, same speeds.			
		H.P.	R.P.M.	H.P.	R.P.M.	H.P.	R.P.M.	H.P.	R.P.M.
Natural Gas.....	140 lbs.	40 30	325 250	60 45	290 220	75 60	275 225	110 85	260 200
City Gas........	125 lbs.	40 30	325 250	60 45	290 220	75 60	275 225	110 85	260 200
Gasoline or Distillate..........	75 lbs. to 100 lbs.	35 30	325 275	55 45	290 240	70 60	275 235	100 85	260 220
Gasoline or Distillate with Water	100 lbs. to 125 lbs.	40	325	65	290	80	275	120	260
Producer Gas....	160 lbs. to 180 lbs.	30 25	325 275	45	290	55	275	85	260
Over all space		5′–0″x10′–0″		11′–6″x5′–7″		12′–6″x6′–0″ Twinned 12′–6″x11′–6″		14′–0″x6′–10″ Twinned 14′–0″x13′–6″	

THE HEER ENGINE COMPANY

PORTSMOUTH, OHIO

HIGH GRADE GAS AND GASOLINE ENGINES

Stationary, Portable and Traction



For all general stationary power purposes this engine is our standard type, adapted to mills, factories, workshops, mines, electric lighting plants, and in fact, any place where absolutely steady and reliable power is required.

THE HEER TWO CYLINDER OPPOSED ENGINE

When it is desired to develop power in units of from 5 to 100 H. P. the two cylinder opposed type of gas or gasoline engine gives better satisfaction at less expense for room, fuel, and attendance than any other prime mover.

The Two Cylinder Opposed requires no excess weight to hold it in place—its perfect balance and evenness of construction retains its equilibrium and requires absolutely no re-adjustment when moved to another location. In the elimination of vibration there is naturally a saving of its energy, thus developing greater power at a lesser cost.

Another very important feature and advantage of the Two Cylinder Opposed is the securing of practically two engines in one or an emergency plant in case one cylinder gets out of order or needs repairing for any cause; it can be disconnected instantly without loss of time and the engine will run indefinitely on one cylinder. This is a very valuable feature which any user of power will appreciate.

CONSTRUCTIONAL FEATURES

Four Cycle Operation conceded most economical of fuel.

Mixer or *Carburetor* a combination, if desired can be used for gas or gasoline, and changed from either fuel to the other without stopping the engine.

Fuel may be natural or manufactured gas, gasoline, California distillate, kerosene, solar oil, or Oklahoma distillate.

Ignition is Jump Spark, the simplest and most reliable.

Speed is controlled by governor and can be changed as desired.

Power and *Test.* A brake test is given each engine, and all engines are rated at less than their brake horse power.

DIMENSIONS OF STATIONARY TYPES

Size of Engine in Rated Horse Power	10 H. P.	16 H. P.	25 H. P.	40 H. P.
Bore of Cylinder	5″	6″	7″	9″
Stroke	5	6	7	10
Diameter of Crank Shaft in Pins and Bearings	2	2⅜	2¾	4
Crank Shaft Extended on One End for Pulley	6	8	10	12
Full Length of Crank Shaft Regular	31⅛	37⅛	43⅛	57⅜
Full Length of Crank Shaft Extended both ends	36⅝	44⅝	52⅝	68⅞
Length of Base at Bottom	40	46¾	53½	66
Width of Base at Bottom	20	23	26	34
Length of Engine over all	50⅞	59⅞	68¾	99½
Width of Engine over all Regular	31⅛	37⅛	43⅛	57⅛
Diameter of Fly Wheels	26	30½	35	48
Pulley any size up to (Larger Size Extra)	14	16	24	30
Revolutions per Minute (Normal)	600	500	450	350
Total Weight of Complete Engine	800	1300	2200	5200
Style Number	20	21	22	23

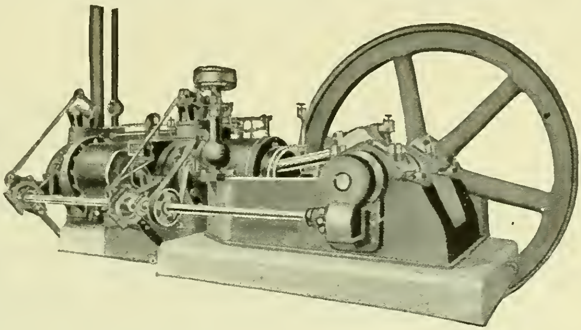
Write for Catalogue.

THE ST. MARYS MACHINE CO.

ST. MARYS, OHIO

OIL ENGINES AND SUCTION GAS PRODUCERS; HEAVY-DUTY TANDEM ENGINES; SINGLE-CYLINDER SOLAR OIL AND DISTILLATE ENGINES; PORTABLE ENGINES; TRACTION ENGINES. ENGINES FOR EVERY POWER PURPOSE.

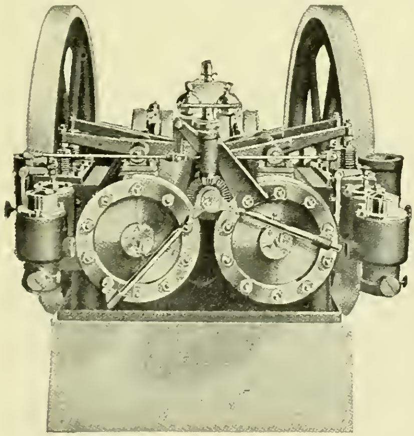
HEAVY-DUTY TANDEM GAS ENGINE
Maximum Size 480 h.p.



This engine operates on the four-stroke cycle. There are two cylinders arranged tandem, each having one single-acting piston. The two pistons are connected by a water-cooled piston rod, the front piston serving as a cross-head carrying the wrist pin, and but one connecting rod and crank is necessary as the pistons move together. This engine lends itself to various combinations for increasing the power of a plant.

DUPLEX SOLAR OIL ENGINES
50 h.p. up to 150 h.p.

This engine is designed for use with natural gas, city gas, gasoline, distillate, solar and crude oils, and is of the throttle-controlled type. An impulse is obtained at each revolution, resulting in greater steadiness.



The regulating device on these engines consists in vertical balanced valves which are moved by the governor and actuated by levers. The air and gas valve areas are proportioned to supply gas and air in the proper proportions to form an inflammable mixture of constant quality in any quantity that the governor may demand.

The lay shaft, igniter, eccentric, governor and pump are common to both cylinders. Each cylinder has its own regular mixing chamber attached directly to throttling chamber, doing away with long intake pipes that cause a governor to operate so sluggishly. This insures the correct amount of mixture in both cylinders, and at no time is the explosion greater in one cylinder than in the other or than the horse power required, hence a steady power.

SINGLE-CYLINDER SOLAR OIL ENGINES
10 h.p. up to 90 h.p.

These engines operate on the four-cycle plan and are designed to embody every feature calculated to insure the greatest strength and symmetrical appearance of the engine.

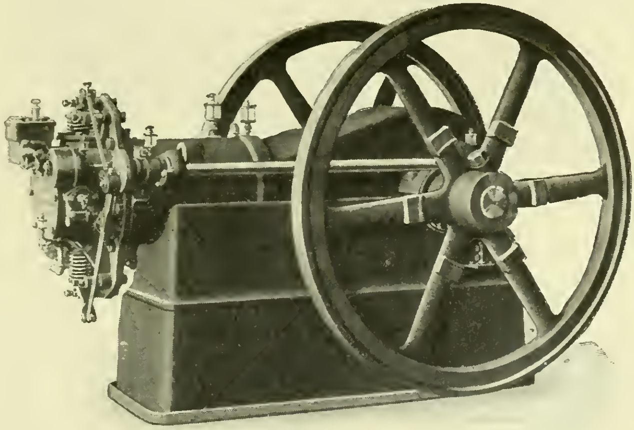
THE WISCONSIN ENGINE CO.

CORLISS, WISCONSIN

COMPLETE PLANTS

GAS OIL STEAM

ADAMS WISCONSIN GAS ENGINES. ADAMS WISCONSIN KEROSENE GAS ENGINES. WISCONSIN HIGHER SPEED CORLISS ENGINES. PRODUCERS TO FIT THE FUEL: ANTHRACITE, BITUMINOUS, LIGNITE, OIL PRODUCERS.



ADAMS-WISCONSIN KEROSENE GAS ENGINE

Capacity 50 BHP to 200 BHP. Built under Rumely patents. Gasifies and uses kerosene, gas oil, naphtha or gasoline. All these oils are gasified in a cold carburetor exactly as gasoline is gasified. 200,000 HP now in use.

WISCONSIN HIGHER SPEED CORLISS ENGINE

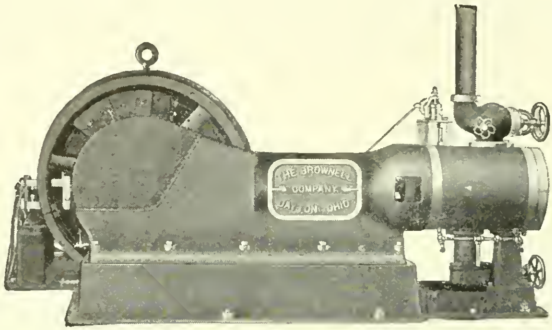
A heavy duty engine, built in capacities 100 HP to 12,000 HP, for all purposes. Highest efficiency for those who demand the best. Bulletin C-4 tells the details.

The Badger Engine Jack turns an engine over. Uses steam or compressed air. Get the story—Ask for Bulletin C-5.

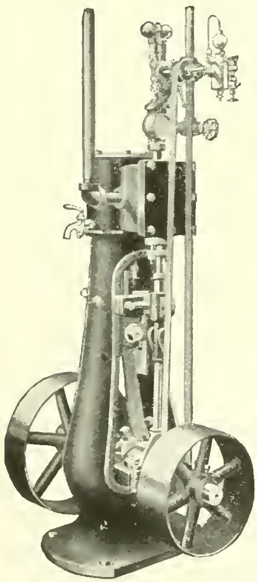
THE BROWNELL CO.

DAYTON, OHIO

ENGINES, BOILERS, FEED WATER HEATERS AND TANKS



SIMPLE AND COMPOUND ENGINES
PLAIN SLIDE VALVE AND AUTOMATIC
BELTED OR DIRECT CONNECTED
OF ALL SIZES AND FOR ALL PURPOSES



"DAYTON" VERTICAL STEAM ENGINES
for Simplicity and Small Floor Space.

Carried in Stock:

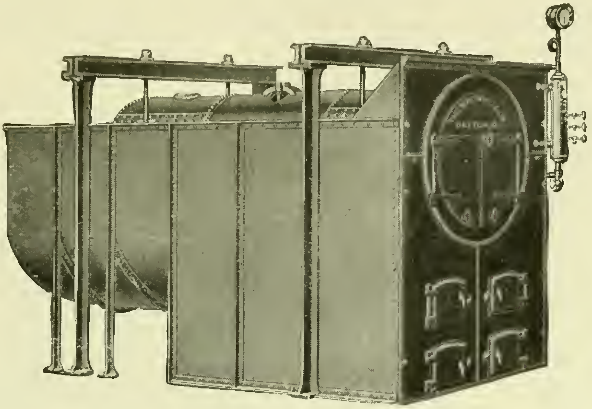
From	$3\frac{1}{2} \times 4$	2 H.P.
To	$7\frac{1}{2} \times 8$	16 H.P.

This engine is furnished separately or combined with our Vertical boiler on one solid base. The combined outfit makes an ideal self-contained power plant and cannot be equalled for compactness, simplicity and ease of operation

Our Data Bulletin No. D–112 will be useful to you, and will be mailed upon request to Managers, Superintendents and Engineers.

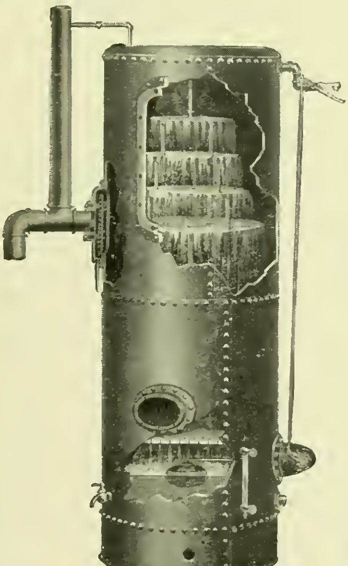
THE BROWNELL CO.

DAYTON, OHIO



BOILERS OF EVERY CLASS AND SIZE
FOR ANY CONDITION OF SERVICE

All of our Boilers are built under the direct inspection of, and tested by, a special licensed boiler inspector of the Hartford Steam Boiler Inspection and Insurance Company, and will be insured for one year *free of charge*, if desired.



FEED WATER HEATERS AND LIME EXTRACTORS, OPEN AND CLOSED TYPES

Percents you save in fuel consumption by heating feed water:

Final Temperature	Initial Temperature of Water				
	32°	40°	50°	60°	70°
60°	2 39	1 71	0.86		
80	4.09	3 43	2 59	1.74	0 88
100	5.79	5.14	4 32	3.49	2.64
120	7.50	6.85	6 05	5.23	4.40
140	9 20	8.57	7 77	6.97	6 15
160	10.90	10 28	9 50	8.72	7.91
180	12.60	12.00	11 23	10.46	9 68
200	14.30	13.71	13 00	12 20	11.43

Our Data Bulletin No. D–112 will be useful to you, and will be mailed upon request to Managers, Superintendents and Engineers.

THE KENNICOTT COMPANY

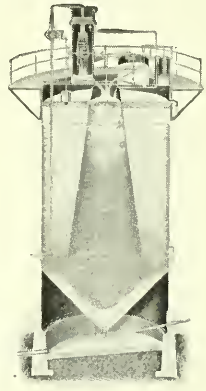
CHICAGO HEIGHTS, ILL.

Sales Office
14th Floor Corn Exchange Bank Building,
Chicago, Ill.

Eastern Office
50 Church Street,
New York, N. Y.

WATER SOFTENERS FOR THE TREATMENT OF WATER FOR BOILER FEED PURPOSES, FOR RAILROADS AND INDUSTRIAL PLANTS, FOR THE USE OF LAUNDRIES, TANNERIES, DYE WORKS, AND ANYWHERE WHERE A SOFT, CLEAR WATER IS OF ADVANTAGE.

DESCRIPTION OF OUR TYPE "K" WATER SOFTENER



The type "K" KENNICOTT WATER SOFTENER, a sectional view of the same being shown at the right of this description, represents the many years' experience which THE KENNICOTT COMPANY has had in WATER SOFTENING.

In order to have a perfect water softener it is necessary to have a machine that will automatically treat varying quantities of water with varying quantities of materials, and which will require the least possible amount of attention and soften a water at the lowest possible cost. This has been accomplished in our type "K" machine.

This machine is continuous in its action, automatically starting and stopping with the beginning and ceasing of the flow of the water into the softener. The water is pumped but once into the softener, and it is delivered at the top. The water as it flows into the softener furnishes all the power the apparatus requires, both for mixing the chemical reagents of the water to be purified as well as for operating automatically all the mechanism of the apparatus. One great particular advantage of this machine is that the parts *REGULATING* the feed of chemicals do not come in contact with the chemicals and, therefore, cannot be subject to stoppage and cannot in any way be affected by the chemicals.

The conical down-take in the softener, and thorough mixing which the water receives in the top of the down-take is of the greatest possible advantage in reaction and sedimentation. By the above means the water becomes quiet as quickly as possible after being thoroughly mixed with the chemicals. The softeners are designed so that the rate of flow in inches per hour is low and sedimentation, therefore, takes place very rapidly.

The softeners are designed to be either top operated, where it is necessary to economize on ground space, or all the chemical mixing and feeding tanks can be located on the ground.

Many machines of both types can be seen in operation and have been in operation for several years.

This type "K" softener has been built in every size from 150,000 gallons of water per hour to 500 gallons of water per hour. The largest CONTINUOUS STEEL TANK SOFTENER in the world having been built and installed by THE KENNICOTT COMPANY. All our experience has been directed towards building a machine which is guaranteed to produce uniform results and WE HAVE MADE GOOD.

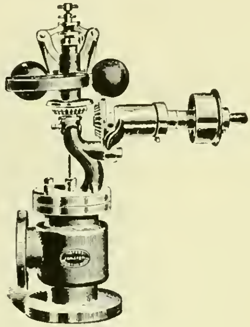
We publish a full description of the operation of this type "K" softener which gives detailed information and also gives photographs of many of the softeners which have been installed for some of the best known firms and railroads in this country and abroad. They cover almost every line of business. The matter referred to will be mailed you upon request.

WATERS GOVERNOR COMPANY

1122 Oliver Bldg., BOSTON, MASS.

REDUCING VALVES AND ENGINE GOVERNORS

ENGINE GOVERNORS

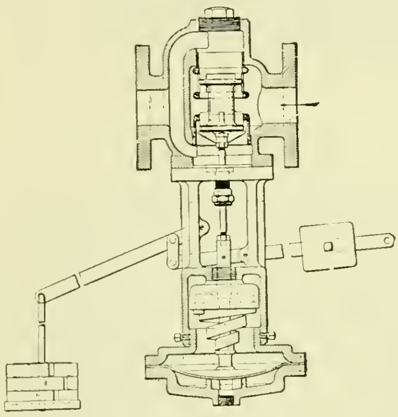


These Governors are suitable for every variety of stationary and portable steam engine. They have adjustable speed regulation, automatic safety stop, Sawyer's lever, solid composition valves and seats, and all parts interchangeable.

The Waters Governors have been in use over forty years and have steadily grown in favor since their introduction. The design is such that they are not affected by the action of gravity, the weight remaining always in the same plane. The valve is of large area, greatly in excess of the steam pipe, and being quick acting and sensitive, insures economical results as well as close regulation. The valves are evenly balanced and have large openings with small travel.

Catalog on Request.

REDUCING VALVES



The accompanying illustration shows our Improved Reducing Valve. The "simplicity" of its construction can readily be seen and appreciated, while its "accessibility" can also be noted at a glance.

Diaphragm is connected by a ½ inch pipe with the low pressure side, and the pressure in the diaphragm chamber, working against the spring, tends to close the valve, spring opening the valve when the pressure falls. A wide range of reduced pressures can be easily and quickly obtained. Particularly desirable for steam heating purposes. The square weight, fastened with a set screw, is simply a counterweight, to be moved in or out as the case may be, to obtain any pressure in between any two weights placed on the scale pan. These valves require no head room, hanging below the line of piping, and can be removed downward, leaving valve chamber only in line of pipe.

We wish to emphasize the fact that with Waters Valves it is not necessary to buy a special valve with outlet larger than inlet, at increased cost. With our valves an enlarged outlet flange answers exactly the same purpose, because the control to operate our valve is taken outside the valve itself. Valves and seats made of a special mixture can be furnished for use with superheated steam. All parts made interchangeable. Our diaphragms are made of special flat stock and shape themselves. In an emergency any good sheet packing can be used temporarily. A special valve for vacuum heating systems is made with very large diaphragm and double-ended single lever, to reduce to atmosphere or below.

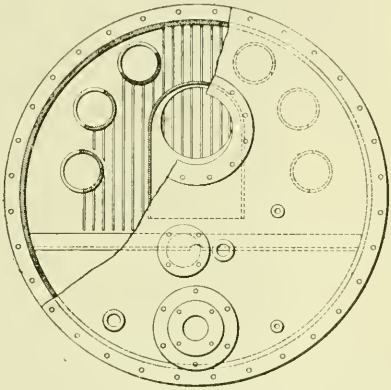
Write for Catalog.

THE NATIONAL PIPE BENDING CO.

THE OIL SEPARATOR

The Oil Separator is part of the Heater and forms the back head and is of the same diameter as the shell. It is of the gravity type, having a multi-ported baffle plate, each port having an individual baffle.

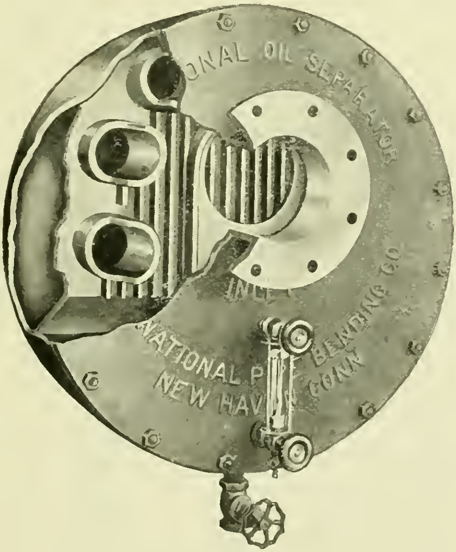
These individual baffles are obtained by having an opening in the back of pipes which extend from the ports in baffle plate to the outer wall of the Separator. They absolutely prevent oil from being carried into the heater. The large cubical capacity of the Separator not only insures the effective separation of oil from the exhaust steam, but it also overcomes the pulsations of exhaust and gives an even flow of steam to the heater.



Oil Separator (Part of the Heater itself)

FILTRATION

Upward filtration is used. A large sediment chamber in the bottom of heater relieves filter bed of unnecessary work. A quick-opening blow-off valve on outlet from sediment chamber affords opportunity for draining heater and also causes a reverse current through filter bed, giving it longer life.



Patent applied for

THE NATIONAL HORIZONTAL OIL SEPARATOR

This Separator absolutely removes the grease or cylinder oil from exhaust steam so that the steam, when condensed, is perfectly suitable for boiler feed, laundry, or dye house service, ice making, or any other similar purpose.

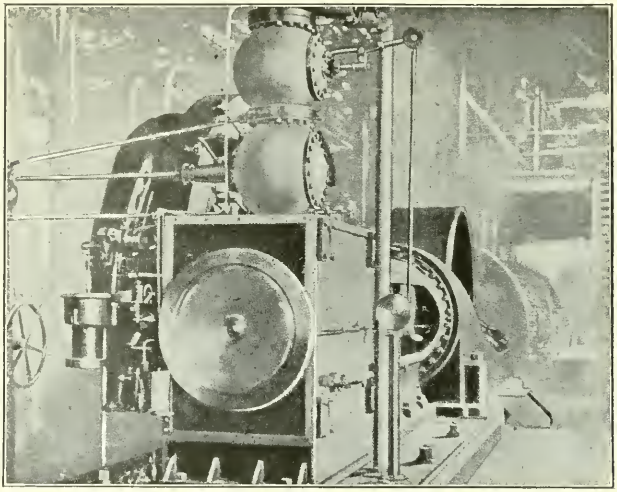
Note the multi-ported baffle plate, each port having an individual baffle, a distinctive feature found only in the National Separators.

THE STRONG, CARLISLE & HAMMOND CO.

CLEVELAND, OHIO

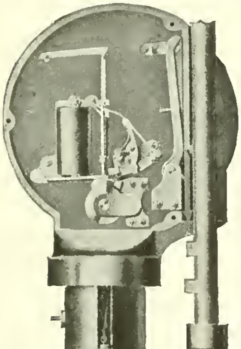
STRONG ENGINE STOP, STRONG STEAM TRAP, STRONG SEPARATORS FOR OIL OR STEAM, STRONG VACUUM TRAPS, STRONG REDUCING VALVES, STRONG PUMP GOVERNOR AND PRESSURE REGULATOR.

THE STRONG ENGINE STOP



One of ten engines in large mill equipped with this apparatus

The Strong Engine Stop is composed of three main parts, the quick-closing valve, the trip head, and the speed limit. The stop may be operated electrically or mechanically or by combining the two methods.

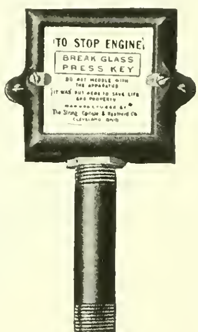


Trip Head Combined Electrical and Mechanical

Whether electrically or mechanically operated the result is the same: over-speeding of the engine is impossible. The "Speed Limit" device at the first instant of "Running Away," as evidenced by the increased speed of the line shaft, throws out a trip, which lets fall a rod and operates the "Quick Closing Valve." As soon as the trip is released, an alarm bell starts ringing and continues to ring until the trip head is reset. The engine having been brought to a stop by the closing of the quick acting valve, cannot be started until the stop has been reset.

CIRCUIT CLOSERS

At any desired points in the Engine room or about the mill, circuit closers may be installed as shown in the accompanying illustrations, the action of which in stopping the engine is practically instantaneous.



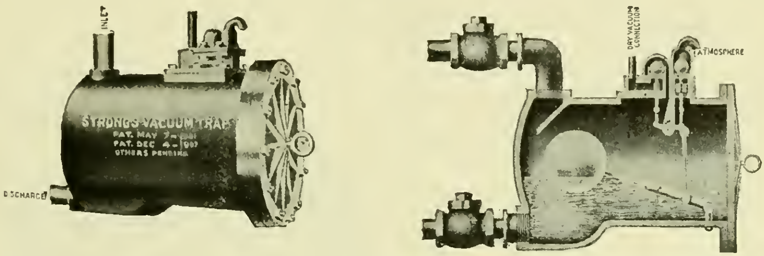
Circuit Closer for Strong Engine Stop

NO BELTS, CHAINS, GOVERNORS, ETC.

The action of the Strong Engine Stop is not dependent upon any of the devices named above, but is so simple and effective that we sell and install it under the same guarantee that applies to all "Strong" Specialties.

"We don't want a cent of money until you are satisfied."

THE STRONG, CARLISLE & HAMMOND CO.



Strong Vacuum Trap

The Strong Vacuum Trap automatically removes water from the vacuum lines of condensing engines, from the receivers of compound engines, from vacuum oil separators, etc., thus preventing accidents which might otherwise occur from the back suction of water into engine cylinders.

The Strong Vacuum Trap is also designed for returning condensation from coils, radiators, etc. of low pressure heating systems, direct to the boiler.

CONSTRUCTION.—The Trap consists of a cylindrical shaped body made from a high grade of cast iron, to which is bolted the head. This joint is machined and absolutely tight. To the top of the trap is attached the frame for the valves with a dry vacuum and atmosphere ports as shown by cut. Into this frame are screwed the seats for the vacuum and atmospheric valves. The valves consist of ground brass balls, operated by levers having heavy phosphor bronze bearings. The mechanism is operated by a Hercules patented copper float connected by heavy phosphor bronze and brass rods. No steel or iron is used in the working parts. The traps have no trunnions to adjust, no stuffing boxes to pack, no tilting devices to balance, and REQUIRE NO STEAM TO OPERATE THEM when discharging the water to the atmosphere and only a sufficient amount of steam to balance the back pressure when discharging to an elevation.

There is not a delicate part in their construction. The valves are in the top of the trap and may be inspected by removing the small caps encasing them. It is impossible for dirt to get at the working parts, as they are above the water line and almost the length of the trap away from the inlet. Every trap is inspected and rechecked before leaving our factory, and is ready to go into service.

TABLE OF SIZES AND CAPACITIES

Size No.	Outlet and Inlet	Distance Floor to Inlet	Total Length	Total Height	Diameter Body	Diameter Flange	Capacity Gallons Hour—Over	Shipping Weight	List Price
	Inches	Inches (Center of Inlet)	Inches	Inches	Inches	Inches			
8	1½	16	24	23	11	14	400	235	$120.00
9	2	21½	28	29	18	20½	700	410	200.00
10	2½	21½	28	29	18	20½	1000	410	200.00
11	3	21½	28	29	18	20½	1600	410	200.00

Swing check valves are furnished for inlet and outlet. Ball and lift checks should not be used

Discount on application

THE FOSKETT & BISHOP CO.

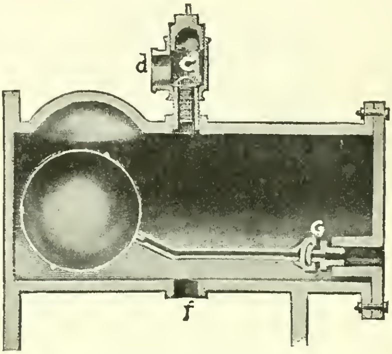
NEW HAVEN, CONN.

ENGINEERS AND CONTRACTORS, POWER PLANTS, GRINNEL AUTOMATIC SPRINKLERS AND APPLIANCES, HEATING, PLUMBING AND GAS FITTING, STEAM TRAPS, STEAM SPECIALTIES

THE FOSKETT & BISHOP PATENT IMPROVED STEAM TRAPS

DESCRIPTION.—The valve comprises the seat which screws into the head, and a disk which is attached to the seat by a hinge and has composition packing set in a slot made in said disk.

G is a heavy copper ball or float tested at a pressure of 300 pounds per square inch, attached by a brass rod to the disk of said valve. The outlet in head is where the water is discharged from the trap; D is the steam and water inlet; C is a copper strainer or basket; H is a plug, by unscrewing which access is had to the strainer for cleaning it; F is an outlet for drawing off all the water from the trap if desired, or discharging water of condensation when exhaust steam is used.



Patent Improved Steam Trap

OPERATION.—When steam is let on to radiators or coils to which the trap is attached, the water flows before the steam into the shell until the float G is raised, which lifts the disk from the seat of the valve and the water is discharged through outlet in head. When enough water is thus discharged to allow float G to fall, the valve is closed and the water again accumulates preparatory to another discharge; so it continues to work, never failing to discharge the water if enough is present to raise the float.

STANDARD SERVICE.—These Traps are recommended for any service requiring the removal of water of condensation without escape of the steam behind it.

For draining the condensation from steam pipes, coils, and apparatus employed in steam heating, steam kettles, vacuum pans, mash kettles, steam engine supply pipes and separators, evaporating pans, steam jackets on engines and pumps, ice machine stills, etc.

PRESSURE CONDITIONS.—In ordering it is important that the steam pressure under which they are to be used should be stated.

The Standard Trap is designed for an extreme pressure of 100 pounds, but where this pressure is to be constant, or likely at any time to exceed this limit, it is better to use the extra heavy type.

Where the Trap is to be used under extreme low pressure conditions,—1 to 20 lbs.,—the duty should be specifically stated, in order that a valve of proper area may be supplied. For this duty the Standard Trap is furnished, but with a larger opening than is used for the ordinary service, which is between 20 and 100 lbs.

TRAP CONNECTIONS.—In selecting a Steam Trap for a given duty it should be borne in mind that the size of the inlet in no way governs the capacity of the Trap, therefore the pipe entering Trap at "inlet" may be arranged to suit connections without affecting the operation of the Trap—care being taken that a Trap of proper capacity is selected for the work.

Should the duty exceed the capacity of the largest Trap listed, two or more Traps may be readily placed side by side, connected to a common horizontal header and operated as one Trap, in order to obtain the necessary trappage capacity.

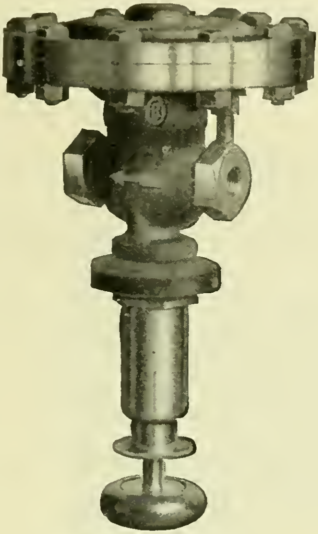
SIZES, DIMENSIONS, CAPACITIES

Number of Trap	0	1	2	3
Size of inlet connection	1 in.	1¼ in.	1¼ in.	2 in.
Size of outlet connection	½ "	½ "	¾ "	1¼ "
Maximum discharge lbs. water per minute	2	4	8	20
Greatest number of lineal feet of 1 inch pipe surface to which trap should be applied	800	1500	4000	10000

THE OHIO BRASS CO.

MANSFIELD, OHIO

OHIO STEAM SPECIALTIES



Ohio Regulating Valve

OHIO PRESSURE REGULATING VALVE

FOR STEAM OR AIR

Patented

Reduces and regulates accurately and continuously.

Self-contained, no tight fits, will not stick.

Simple and rugged in construction.

Made in all bronze in ½ to 2 inches.

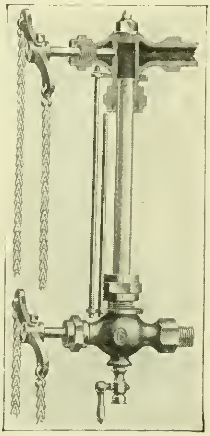
Made in iron body with bronze working parts in 2½ to 4 inches.

OHIO WATER GAUGE

Comes packed with high grade packing, ready to use.

Quick opening—opens or closes with a quarter turn of levers.

Made of high grade steam bronze in ½ and ¾ inch.



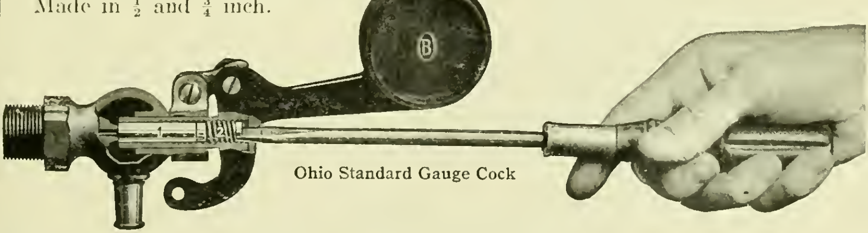
Ohio Water Gauge

OHIO STANDARD GAUGE COCK

A simple twist of the wrist stops a leak.

Has babbitt disc "1" which is rotated to a tight seat by screw "2."

Made in ½ and ¾ inch.



Ohio Standard Gauge Cock

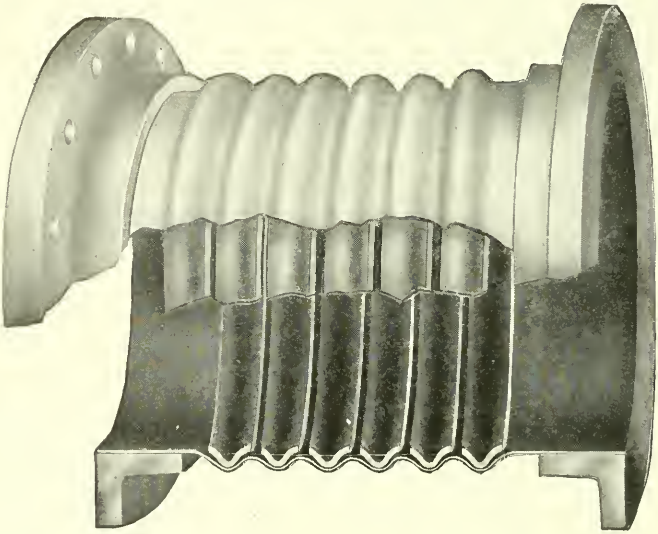
Descriptive Catalog M.E. mailed on request

E. B. BADGER & SONS CO

63-75 PITT ST.

BOSTON, MASS.

COPPER EXPANSION JOINTS



BADGER'S COPPER EXPANSION JOINTS

Will take care of the expansion and contraction in pipe lines, absorb vibration in engine and turbine exhausts, etc.

Our regular joints are built in sizes from 1″ to 7′ 0″ in diameter; larger joints constructed for special work.

These joints may be employed in high pressure, vacuum or exhaust lines; the construction suits the particular case.

The principal difficulty with expansion joints has been in the unequal distribution of the expansion among the different corrugations, resulting in excessive strain on, and probably rupture of, one of the corrugations.

Our patented internal and external equalizing ring construction prevents any one corrugation from doing more than its share of the work, and provides at the same time a stiffer and stronger joint.

As to amount of expansion: Our 12″ diameter, 3 corrugation, 12″ face to face joint will take up easily 1½″ expansion; others in proportion to diameter, number and size of corrugations, etc.

Unless otherwise specified, we furnish standard A.S.M.E. flanges.

Write for full particulars.

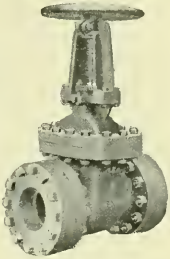
PITTSBURGH VALVE, FOUNDRY & CONSTRUCTION CO.

PITTSBURGH, PA.

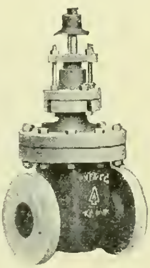
GATE VALVES

50 lb. Parallel Seat Gate Valve. Close Pattern

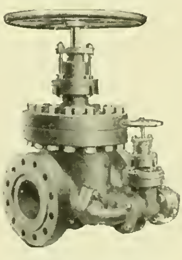
SPECIFICATIONS FOR MATERIAL	Grey Iron—22,000 lb. per sq. in. tensile strength. Semi Steel—33,000 lb. per sq. in. tensile strength.
PARALLEL SEAT 50 lb. WORKING PRESSURE 100 lb. TEST PRESSURE	Sizes 14″ to 72″ cast iron. Low pressure. For water, gas, air or exhaust steam. Extremely close face to face, invaluable in complicated piping connections.
PARALLEL SEAT 125 lb. WORKING PRESSURE 300 lb. TEST PRESSURE	Sizes 2″ to 48″ cast iron. Standard pressure. For water, air, steam or gas. Fully bronze mounted. Especially adapted to water distribution.
PARALLEL SEAT 200 lb. WORKING PRESSURE 400 lb. TEST PRESSURE	Sizes 1½″ to 16″ cast iron. Largely used for natural gas under the lower pressures. Furnished either all iron or iron body bronze mounted.
PARALLEL SEAT 400 lb. WORKING PRESSURE 800 lb. TEST PRESSURE	Sizes 3″ to 20″ semi steel. In extensive use for the transmission of natural gas. Furnished either with or without bronze mountings.
PARALLEL SEAT 500 lb. WORKING PRESSURE 1500 lb. TEST PRESSURE	Sizes 2″ to 12″. For water or oil at pressure noted. Semi steel with solid bronze mountings.
PARALLEL SEAT 1000 lb. WORKING PRESSURE 1500 lb. TEST PRESSURE	Sizes 2″ to 12″ semi steel. High pressure gas valve used chiefly at the gas wells and on feeders in the gas fields.
PARALLEL SEAT 1500 lb. WORKING PRESSURE 2000 lb. TEST PRESSURE	Sizes 2″ to 10″ semi steel. For hydraulic service and extreme natural gas rock pressures.
TAPER SEAT 175 lb. WORKING PRESSURE 500 lb. TEST PRESSURE	Sizes 2″ to 16″ semi steel. A valve for medium steam pressures from 125 lb. to 175 lb. where a less expensive valve than the 250 lb. type is desired.
TAPER SEAT 250 lb. WORKING PRESSURE 800 lb. TEST PRESSURE	Sizes 1½″ to 28″ semi steel Made of semi steel with solid bronze mountings for ordinary steam pressures or of cast steel with monel mountings for superheat.
TAPER SEAT 1000 lb. WORKING PRESSURE 2000 lb. TEST PRESSURE	Sizes 2″ to 10″. The strongest valve possible to make in its weight, all surfaces being cylindrical or spherical segments.
GATE VALVES FOR ANY PRESSURE	Designs and quotations furnished for valves for special conditions or higher pressures. Materials used are those best adapted to service.



8″ 500 lb. Gate Valve



4″ 1000 lb Gas Line Gate Valve



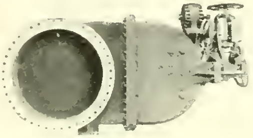
8″ 1000 lb. Hydraulic Gate Valve

(See also next page)

(Continued from preceding pages)

PITTSBURGH VALVE, FOUNDRY & CONSTRUCTION CO.

PITTSBURGH, PA.

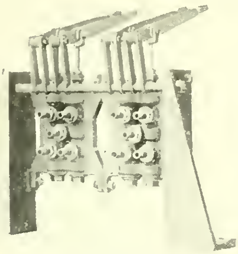


48″ Motor Operated Gate Valve

30″ Gate Valve Operated by Air Cylinder

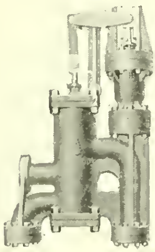
Any of the foregoing gate valves may be equipped with operating cylinders for any service or pressure, or motors for either direct or alternating current.

The following types of operating valves are extensively used for the control of motion of hydraulic cylinders, either single or double acting.



Group of Two Critchlow Nests

The **CRITCHLOW VALVE** is the simplest form of hydraulic three or four way piston valve and has no superior for working pressures up to 500 pounds. It is durable and easy to repack. The CRITCHLOW NEST furnishes a means of grouping these valves which yields a great saving in pipe, fittings, manifolds and space, where a number of cylinders are to be operated from one pulpit.

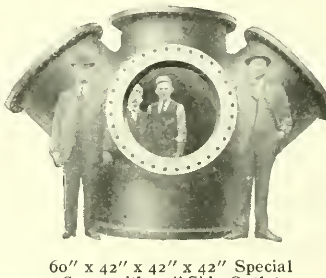


Tanner Valve with Actuating Cylinder

The **TANNER VALVE** is more satisfactory than the Critchlow on high pressures. It is of the cup-packed piston type, so designed that the fluid forces the packing away from the ports instead of into them, prolonging the life of the packing and making operation easy. The arrangement of supply and waste ports facilitates attaching to manifolds. Larger sizes can be furnished with actuating cylinder permitting remote control by means of a pilot valve.

The **AIKEN VALVE** has given complete satisfaction to a large number of users for many years. The designs and patterns for this valve have been purchased from the inventor, Henry Aiken, M.E., and valves can be made to meet any requirements.

Special facilities for casting and machining large pipe and fittings as well as all classes of work such as furnace castings, general castings, etc.



60″ x 42″ x 42″ x 42″ Special Cross with 30″ Side Outlet

PITTSBURGH VALVE, FOUNDRY & CONSTRUCTION CO.

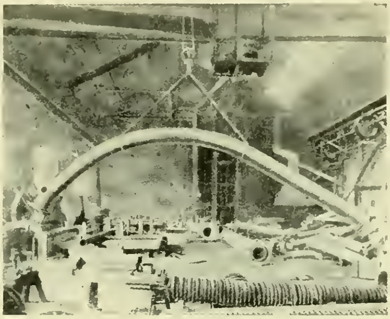
PITTSBURGH, PA.

PIPING SYSTEMS

For all Pressures and Purposes, Designed, Manufactured and Installed

Pipe Bending Pipe Cutting
Pipe Fitting

Estimates furnished on receipt of specifications

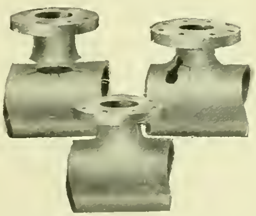


20″ Expansion Bend—Radius 16 Ft.
This bend contains 38 ft. of pipe and was made of two lengths joined in the arc by the Atwood Line Weld

The Atwood Line Weld
Patented

THE ATWOOD LINE WELD

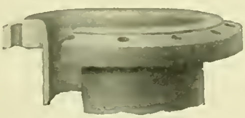
This method of joining the abutting ends of wrought pipe allows the fabrication of pipes into lengths as long as can be handled for shipment with consequent reduction by about 50 per cent of the number of flanged joints in the line.



The Interlock Welded Neck
Patented

INTERLOCK WELDED NECKS

This method of connecting branch lines of wrought pipe to mains of the same material was developed in response to the demand of steam users for a structure containing the minimum number of joints. Every branch so connected eliminates a cast fitting with its attendant joints, gaskets and bolts and liability to trouble therefrom.



The Atwood Joint

FLANGED JOINTS

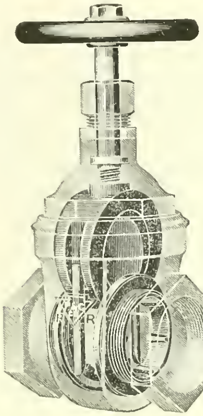
Atwood, Screwed, Shrunk, Expanded and Welded.

Trade Mark
A
ATWOOD

THE PRATT AND CADY COMPANY

HARTFORD, CONN.

VALVES FOR ALL PURPOSES



GATE VALVES

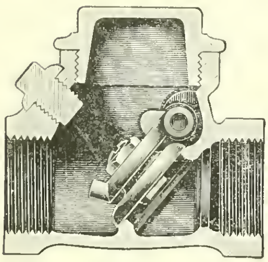
With renewable seat rings, held in place by a retaining ring that is easily removed.

Screw Hub, Stationary Spindle, Retaining Ring Construction.

The seat rings are independent rings of bronze, or any special metal or material best adapted for the service in which the valve is to be used. The gate is a double faced, wedge shaped casting, with side grooves by means of which it slides on guides in the valve body.

Great pains are taken in the machining of all parts of these gate valves. Gauges are used on each part to insure their accuracy and interchangeability.

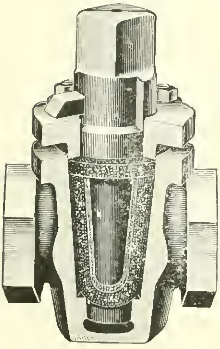
The guides in our bodies are of equal thickness, and the wedge can be taken out of the valve and replaced with the opposite faces in contact, and will give an accurate fit. The importance of this in making repairs is obvious. These valves being double seated, can be used with the pressure applied at either end.



REGRINDING SWING CHECK VALVES

Brass and Iron

All styles for all pressures, sizes up to 48 inches. The *Design* combines pressure resistance with easy flow lines. Material (of brass valves) is 86% pure copper. We use no scrap in their production. *Workmanship* — Each valve is individually tested to the pressure stated in catalog. All seats are carefully ground. Assembling is done by our most careful hands. The *Interior Construction* permits the replacement of any working part without removing valve from line. *For Regrinding* no tool is necessary but a wrench and brace and bit.



ASBESTOS-PACKED COCKS

The dovetailed U-shaped grooves in the body are packed with prepared asbestos. An asbestos ring is used on the shoulder of the plug for top packing.

The plug is of standard taper carefully finished and barffed to render it rustless. It has no metallic bearing, coming in contact only with asbestos, the elasticity of which compensates for the differential expansion and contraction of the plug and body. The gland admits of adjustment by means of its bolts.

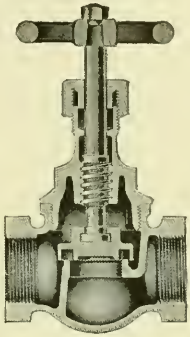
These cocks give exceedingly satisfactory results as a boiler blow-off and a water column blow-off, between check and boiler, between water column and boiler, and they do work where ground plug cocks are unsatisfactory and where Globe, Angle or Gate Valves fail.

THE PRATT AND CADY COMPANY

HARTFORD, CONN.

VALVES FOR ALL PURPOSES

ASBESTOS DISC VALVES



The Stuffing Box Gland is long, heavy and well fitted.

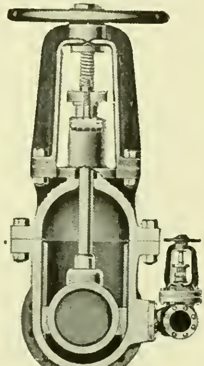
The Spindle Collar, and its point of contact with the bonnet, have specially smooth surfaces and make a steam-tight joint when valve is fully open.

The Disc Holder is guided by four splines in the body, assuring perfect alignment at all times. The Disc Holder is of the horseshoe type, and can be removed and replaced, the only tool necessary therefor being a wrench to unscrew the bonnet.

The Seat is spherical, thus preventing the settling thereon of any substance that might hold the disc from going squarely to its place. The metal used in the construction of these valves is approximately 86% pure copper. We use no scrap whatever in the construction.

The Valve complete is finished with the utmost care. When so ordered, these valves can be made with solid brass disc, or with brass disc holder filled with special metal, at additional price.

CAST STEEL GATE VALVES FOR SUPER-HEATED STEAM



All Valves 2½″ and larger are equipped with Cast Steel Bodies, Bonnets and Wedges.

The Seats and Faces of the Wedges are made of Pure Nickel, securely fastened in place so that they will be unable to work loose.

Stems are Nickel Steel.

All Bolt Holes are Spot Faced.

Bonnet Joint is packed with "Palmetto" Superheat Packing.

The End Flanges have $\frac{1}{16}$″ Raised Faces, extending full width inside of Bolt Holes, with smooth finish.

All Bolts have Hexagon Heads and Nuts, with the under side of same semi-finished.

The Discs are of the Wedge Pattern.

Stuffing Box is made with Hinge Bolts, very deep for square "Palmetto" Packing.

Yoke is bolted to the Bonnet.

All tested to a hydrostatic pressure of 800 lbs..

COMPRESSION TYPE HYDRANTS

Without Intricacy of Construction.

Complete catalog of all Pratt and Cady products on request.

WALWORTH MANUFACTURING CO.

Established 1842

132 FEDERAL ST., BOSTON, MASS.

Works, South Boston. New York Office, Park Row Building.

Manufacturers of

HEAVY PRESSURE POWER PLANT PIPING MATERIALS

The WALWORTH up-to-date Catalog to be issued in 1912 will give full details, with illustrations, dimension Tables, etc., and will be furnished on request to interested parties. Write Department E.

The following will give you a general idea of our complete line—furnished both STANDARD and EXTRA HEAVY:—

WALMANCO FLANGED-OVER THREADLESS PIPE JOINTS, swivel ends for 250 pounds working pressure.
WALWORTH LONG SWEEP FLANGED AND SCREWED FITTINGS.
WALWORTH WROUGHT IRON OR STEEL PIPE BENDS, with threaded or Walmanco Joints.
WALWORTH ELBOWS, TEES, CROSSES, FLANGES, etc. (Brass and Iron), for all pressures.
"WALCO" MALLEABLE IRON BRASS SEAT UNIONS, ground joint.
FLANGES, Standard and Extra Heavy.
WROUGHT IRON PIPE WITH WELDED FLANGES.
STEEL PIPE DRUMS, with welded pipe nozzles riveted on, using Walmanco or welded flanges.
CAST IRON FLANGED PIPES.
CAST IRON BRACKETS, ROLLER CHAIRS AND FLOOR STANDS.
QUICK CLOSING SAFETY DEVICE FOR WATER GAUGE COLUMNS.
INJECTORS AND POP SAFETY VALVES.
ENGINE AND BOILER TRIMMINGS, WATER GAUGES, etc.

WALWORTH HIGH-GRADE GATE VALVES,

With Renewable Bronze Seats. Outside Screw and Yoke or Stationary Spindle. Spindles either Bronze or Steel. Can be repacked under pressure. Sizes up to 42 inches diameter.
STANDARD IRON BODY BRASS MOUNTED GATE VALVES for 125 pounds working pressure.
MEDIUM IRON BODY BRASS MOUNTED GATE VALVES for 175 pounds working pressure.
EXTRA HEAVY IRON BODY BRASS MOUNTED GATE VALVES for 250 pounds working pressure.
HYDRAULIC BRASS MOUNTED GATE VALVES, for 800 pounds working pressure.
BRASS GATE VALVES, standard and Extra Heavy.
"WALCO" BRASS GATE VALVES, for 125 pounds working pressure,
STANDARD AND EXTRA HEAVY IRON BODY GLOBE AND ANGLE VALVES,
Never-Stick Boiler Blow-off Cocks,
AUTOMATIC STOP VALVES, extra heavy.

For Heavy Pressure Piping we furnish:
WALWORTH SEMI-STEEL CASTINGS
For Drums, Valves and Fittings
(Average Tensile Strength, 33,500 Pounds)

We also manufacture a complete line of Pipe Fitters' Tools, Stocks and Dies, Pipe Cutters, Vises, etc., including the—

TRADE MARK STILLSON REGISTERED U.S. PATENT OFFICE

GENUINE STILLSON WRENCH
which bears the Diamond Trade Mark.

TRADE MARK STILLSON REGISTERED U.S. PATENT OFFICE

S. F. BOWSER & COMPANY, Inc.

Established 1885

FORT WAYNE, IND.

New York Boston Philadelphia Chicago St. Louis
San Francisco Minneapolis Dallas Atlanta Toronto

OIL SYSTEM ENGINEERS AND MANUFACTURERS

Oil System Engineers and Manufacturers of:

Oil Distributing Systems.

Self-Measuring Hand and Power Driven Pumps.

Underground Storage Systems.

Large Tankage.

Oil Storage Systems.

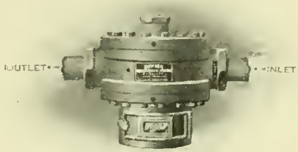
Automobile Filling Stations.

Dry Cleaning Systems.

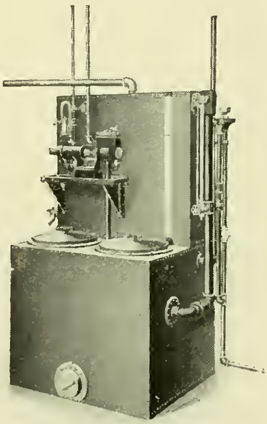
Self-Registering Pipe Line Measures.

Oil and Gasolene Storage Outfits for Public and Private garages.

Oil Filtration and Lubricating Systems.



Registering Measure



Filtration System

The Bowser line covers every requirement of the factory and railroad for oil storage equipment.

Our corps of mechanical and drafting engineers is at the command of those interested in this line.

Bulletins giving complete detailed description of any line will be furnished upon application and without obligation. We have a fund of information on oil storage and allied lines that will assist in making up specification for this work. Let us submit it.

Our catalogue No. 12B illustrates and describes the line in a limited way and shows a large number of installations in widely diversified fields. Write for it.

Oil House

PITTSBURGH GAGE & SUPPLY CO.

PITTSBURGH, PA.

New York City: 136 Liberty St.   Boston, Mass.: 54 High St.   Chicago, Ill.: 174 N. Market St.

LUBRICATING APPLIANCES

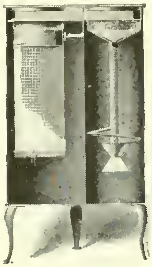
WHITE STAR OIL FILTERS AND OILING SYSTEMS

White Star Oil Filters are made in the following types:

Round: For small plants where a continuous oiling system is not contemplated, and delivery of oil is made to Filter by hand.

Duplex: For use in connection with automatic continuous oiling systems.

Multiplex: For oiling systems in very large plants. They are made for handling as much as 6000 gallons of oil per day.

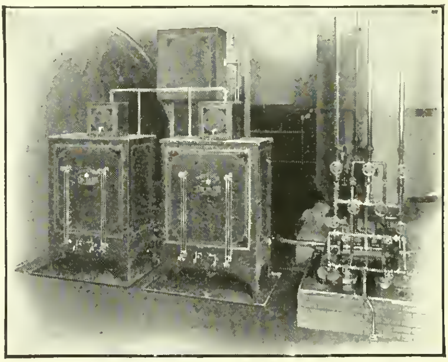


ROUND TYPE

Number of Filter	Filtering Capacity Gallons per 24 Hours	Holding Capacity, Gallons			List Price for Hand Operation	Shipping Weight lbs.
		Pure Oil	Dirty Oil	Water		
2	20	7½	5½	5	$35.00	115
4	35	9½	7½	6½	50.00	127
5	50	12	10	9	60.00	142
7	65	15	13	12	75.00	165
10	80	19	17	16	85.00	190
12	100	25	18	20	100.00	225

DUPLEX AND MULTIPLEX TYPES

Number of Filter	Filtering Capacity, Gallons per 24 Hrs.	Holding Capacity Gallons			List Price	Shipping Weight, lbs.
		Pure Oil	Dirty Oil	Water		
8	100	13	10	8	$95.00	190
17	150	38	11	8	125.00	285
20	200	64	17	14½	150.00	400
23	350	50	30	25	300.00	620
25	500	103	40	45	400.00	850
27	700	100	40	25	500.00	1000
50	1000	115	105	67	600.00	1500
100	2000	235	125	90	800.00	2000
150	3000	353	182	119	1000.00	2500
200	4000	476	257	177	1200.00	3000
250	5000	589	320	236	1500.00	3600
300	6000	710	365	236	1800.00	4200



A Typical Duplex Installation.

On request we will furnish bulletins showing our complete line of special Rotary, Double Acting, Simple and Duplex Pumps, Reservoirs, Separating and Drain Tanks, Sight Feeds, Compression Fittings, Piping Materials and accessories, special oiling devices and Force Feed Cylinder Lubricators.

In addition to manufacturing lubricating appliances, we make:

Gaco Safety Water Gages; a self-closing gage, the valves of which close instantly in case gage glass breaks.

Gaco Take-Down Gage Cocks—can be taken down under full head of boiler pressure.

Pittsburgh Safety Water Columns—Equipped with combined high and low water alarm attachment.

Pittsburgh Steam and Oil Separators—For removal of water and oil from live steam.

Pittsburgh Recording Gages—For recording pressure of steam, oil, gas, air; also vacuum.

Pittsburgh Vacuum Exhaust Heads—For removal of water, oil, etc., from exhaust steam.

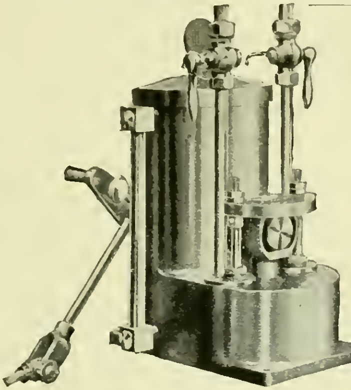
Gaco Dust Collecting Systems.

Pipe Bends and High Pressure Piping Work a specialty.

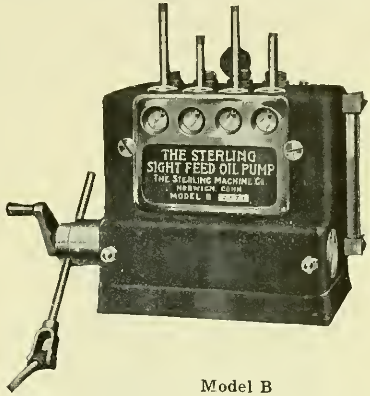
THE STERLING MACHINE COMPANY

NORWICH, CONNECTICUT

ACME ENGINES, STATIONARY AND MARINE; DIRECT CONNECTED GENERATOR UNITS; STERLING LUBRICATORS FOR AUTOMATIC FORCE-FEED LUBRICATION



Model A



Model B

STERLING FORCE FEED LUBRICATORS

are high grade oil pumps for providing positive lubrication with the minimum amount of oil. They are entirely automatic in action and save time as well as oil.

Model A is designed for use on steam engines and pumps and is made in the following sizes:

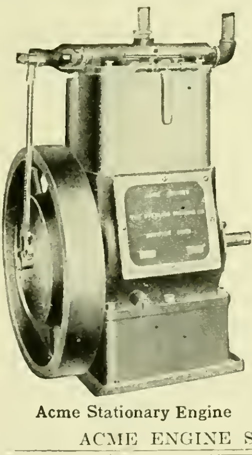
Number of Feeds	One						Two					Three			
Tank Capacity...	1 Pt.	1 Qt.	3 Pt.	½ Gal.	1 Gal.	1½ Gal.	1 Qt.	3 Pt.	½ Gal.	1 Gal.	1½ Gal.	3 Pt.	½ Gal.	1 Gal.	1½ Gal.

Model B is intended for use on large units and is especially adapted for lubricating the valves and cylinders of large gas engines, air compressors and similar units.

This model can be built in any capacity with any number of feeds. Standard sizes as follows:

Number of Feeds	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Tank Capacity...	4 Pt.	5 Pt.	6 Pt.	1 Gal.	1¼ Gal.	1¼ Gal.	1¾ Gal.	1¾ Gal.	2 Gal.	2 Gal.	2¼ Gal.	2¼ Gal.	2¾ Gal.	2¾ Gal.	3 Gal.	3 Gal.

ACME STATIONARY STEAM ENGINE



Acme Stationary Engine

This Engine is an upright, double-cylinder single-acting engine, with cranks 180° to each other; pistons being 1½ times the stroke in length, form their own guides. Cranks are of drop forged steel, large size in diameter and length. Main bearings are 2½ times diameter of shaft, bushed with bronze, and can be renewed when worn, at small cost. Valve is of the balanced rocking type, of extra long and large wearing surfaces, and is placed on top of cylinders, the valve-case forming the cylinder heads. Lubrication is accomplished by carrying in the crank case a mixture of oil and water, into which the cranks dip at every revolution, and are not only flooded themselves, but throw the oil to every part inside the case.

These Engines are especially adapted for Mechanical Stokers, Small Independent Electric Light Equipments, Centrifugal Pumps, and for use with Exhaust or Ventilating Fans, Blowers, etc. Catalogues on request.

ACME ENGINE SIZES FROM ONE HALF TO THIRTY-FIVE H.P.

Engine Model	1	2	3	4	5	6	7	8	9	10
Bore (inches)	2¼	3	3 5/16	3 5/16	4	4 9/16	5	5	6	7
Stroke (inches)	3½	3½	3½	5	5	5	5	7	7	7

Any of the above sizes may be operated at a speed up to 600 R.P.M.

MAGNOLIA METAL CO.

NEW YORK	CHICAGO	MONTREAL
113-115 Bank Street	Fisher Building	225 St. Ambroise St.

MAGNOLIA METAL

TRADE MARK

FAC-SIMILE BAR OF MAGNOLIA METAL

COEFFICIENT OF FRICTION Tests by great governments and eminent mechanical experts all show that Magnolia has the smallest coefficient of friction of any known bearing metal. The United States Government test—when *water* was used as the lubricant—300 lbs. pressure per square inch, 491 R. P. M., showed a frictional coefficient as low as 0.0008. The test by the French Government —710 lbs. pressure per square inch, 6.56 ft. per second—lubricant "black oil," showed coefficient 0.0012.

WEARING QUALITIES Magnolia ran over twenty-three years on log mandrel bearings and was in good condition when plant was permanently shut down. It is the rule rather than the exception for Magnolia lined bearings to run for five and ten years and longer.

HEAVY PRESSURES Thousands have testified that Magnolia is the only metal that will stand the heavy pressure on their bearings: proving superior to and out-wearing bronze and brass in Rolling-mill work, etc. Professor John Goodman, the well known English authority, says of Magnolia—"The higher the pressure that is applied to a Magnolia bearing, the better does the wearing surface become." He tested it up to two tons per square inch.

HIGH SPEED Magnolia is used largely in thousands of wood-working and other plants where both the speed and duty are very severe and is extolled for its lasting and other qualities. It commonly runs in such places from four to fifteen years.

LUBRICATING QUALITIES Magnolia is largely a self lubricating metal. In the *water* test by the U. S. Government Magnolia was run for 5 hours up to 600 lbs. inch^2 pressure—the limit of machine—490 R. P. M., and proved to be 200% superior antifrictionally to a conventional Babbitt of the same formula as Magnolia but not subjected to the same special foundry treatment and 1100% superior to white brass. Magnolia has run six years on shafting bearing without a drop of lubrication and Engineers very often speak of large saving in oil on Magnolia bearings.

GRIT We have great numbers of letters laying particular stress upon the wonderful wearing qualities of Magnolia bearings that are subjected to grit and dust in Cement Mixers, etc. etc.

DETAILS We will gladly send our advertising literature giving full particulars to any one interested.

TAYLOR INSTRUMENT COMPANIES

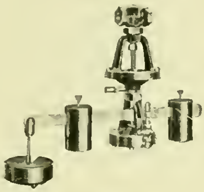
ROCHESTER, N. Y.

"Where *"Tycos"* Thermometers Come From"

NEW YORK	BOSTON	CHICAGO
Bank of Metropolis Bldg.	44 High Street	Heyworth Building
31 Union Square		29 E. Madison St.

MANUFACTURERS OF A COMPLETE LINE OF INSTRUMENTS FOR THE INDICATING, RECORDING AND REGULATING OF TEMPERATURE AND PRESSURE.

"Tycos" Thermometers for every purpose and application, including the famous *"Tycos"* Type; *"Tycos"* Recording Thermometers in both Self-Contained and Capillary form; *"Tycos"* Index Thermometers, etc., Indicating and Recording any range of Temperature from minus 328°F to 1000°F.



H & M *"Tycos"* Automatic Temperature and Pressure Regulators for processes requiring uniformity of Temperature or pressure conditions.

"Tycos" Time Valves, in conjunction with *"Tycos"* Regulators, make it possible to continue a process at a given temperature for a desired period of time, at the expiration of which the steam line is closed off and the exhaust opened, terminating the process.

"Tycos" Rotary Switchboards are made for the control of any number of High Temperature Stations, up to and including twenty.

"Tycos" Pyrometers—

Base-Metal from 200°F to 1800°F.

Rare-Metal from 1000°F to 2500°F.

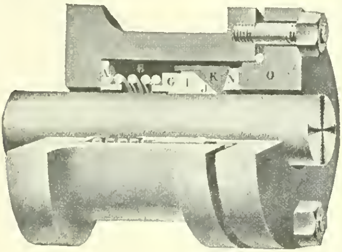
Foster *"Tycos"* Fixed Focus Pyrometer is the most dependable portable instrument.

FERY RADIATION PYROMETER has no top limit. It is extremely sensitive and in action is almost instantaneous.

C. LEE COOK MANUFACTURING CO.

LOUISVILLE, KY., U. S. A.

COOK'S METALLIC PACKING FOR STEAM, GAS AND AIR, ON POWER ENGINES OF EVERY DESCRIPTION; ESPECIALLY ADAPTED TO EXTRA HEAVY DUTY SERVICE ON REVERSING BLOOM MILL ENGINES, BLOWING ENGINES, ROLLING MILL ENGINES, GAS ENGINES, MARINE ENGINES, LOCOMOTIVES, AND ENGINES OPERATING UNDER VERY HIGH STEAM PRESSURE AND SUPERHEAT.

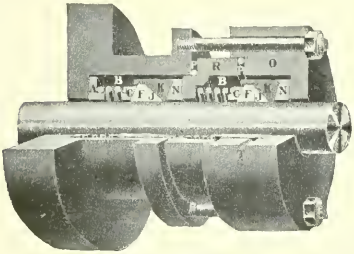


No. 1 Type Packing

SINGLE TYPE PISTON ROD PACKING

Is familiar to every leading engine builder in the United States. We have had satisfactory and agreeable business relations with them all.

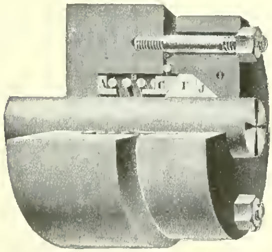
It is simple, and economical as compared with other types of Metallic Packing, and has special merit not afforded by others. An examination of its construction will be proof sufficient that it is *steam tight*, will not cut, or score the rod, and operates with minimum friction.



No. 2 Type Packing

DOUBLE TYPE PISTON ROD PACKING

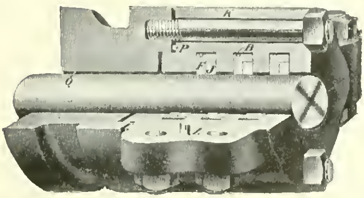
A trying difficulty before the successful operation of Metallic Packing, is the elimination of condensation. We accomplish this by placing two sets of Metallic Packing together, as seen in the cut. The upper, or main set, holds the pressure while the lower set arrests the water and conveys it to the threaded opening "T" of the lower Gland "O." A valve and a drain pipe is attached to this, and after the engine is hot, and condensation reduced to a minimum, the valve may be closed, thus putting into action two sets of packing, operating as one. Result: DOUBLE DURABILITY.



No. 3 Type Packing

CORLISS VALVE STEM PACKING

The cut delineates how simple is this packing's design. It is so near frictionless that there is no appreciable difference offered to the turning of the stem when the packing is on or off. Hence, when this packing is applied, the Valve Gear operates under a uniform condition, and averts the need of continual adjustment of dash-pots. For high vacuum service, we put two sets of this packing together, as illustrated in our Double Piston Rod Packing, and inject a steam seal under pressure through the opening which forms the drain in the former case. This hermetically seals the vacuum.



No. 6 Type Packing

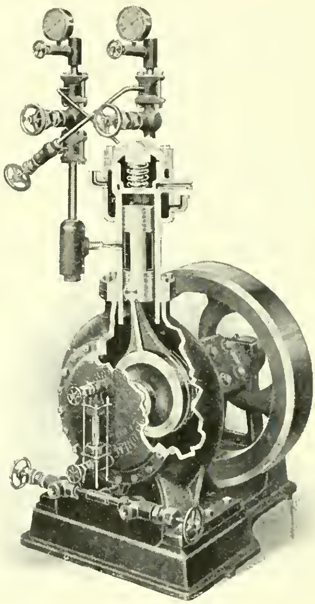
SPLIT PISTON ROD PACKING

The cut delineates our outside type of packing cage, but we make it in any design that requirements or preference demands. Hence we can completely insert it in the stuffing box, using the fiber gland to hold it in place, or we can partly insert it with its outer end in the shape of a flange drilled to receive the studs, and thereby serve as the gland. We make packing rings for this type of packing in over six designs, all depending upon the preference of the engineer and the requirements of the service. A striking innovation in split packings is our copper gasket that forms a joint between the stuffing box and the packing case.

BRUNSWICK REFRIGERATING CO.

NEW BRUNSWICK, N. J., U. S. A.

REFRIGERATING AND ICE MAKING MACHINERY
For Private Residences and Estates.
MARINE REFRIGERATING AND ICE MAKING PLANTS.
COMPLETE PLANTS INSTALLED FOR COMMERCIAL REFRIGERATION OF ANY KIND



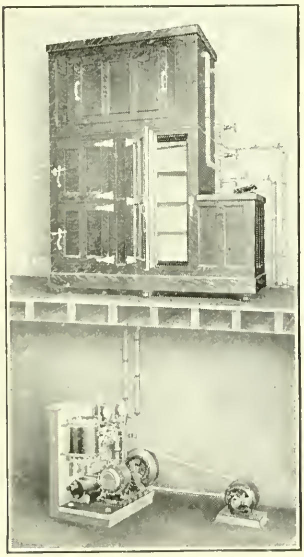
CONSTRUCTION

The "BRUNSWICK" is constructed throughout for maximum strength, efficiency, and durability. For private residence work the "BRUNSWICK" is acknowledged to be the most successful type on account of these features and its simplicity.

The COMPRESSOR is fool proof. Note the eccentric drive; the double set of piston rings; the safety relief valve inside of the discharge valve; the fact that the discharge valve is the full diameter of the cylinder. There is not a bolt or a nut inside of the crank case of the machine.

THE "BRUNSWICK" SYSTEM

"BRUNSWICK" experience has improved not only the compressor, but the whole system from the automatic expansion valve which is used on the smaller units through the expansion side of the plant, through the compressor, condenser, and back to the ammonia receiver. Nothing but the very best and strongest material is used. The fact that there are nearly 1,200 "BRUNSWICK" plants in operation today of 12 tons refrigerating capacity and less, 1,000 of which are under 6 tons capacity, is the best testimony that can be given regarding design, material and workmanship.



APPLICATION

RESIDENCES	Confectioners
STEAMSHIPS	Dairies
Clubs and Cafes	Ice Cream Makers
Office Buildings (ice water)	Butchers
Hotels	Etc., Etc., Etc.

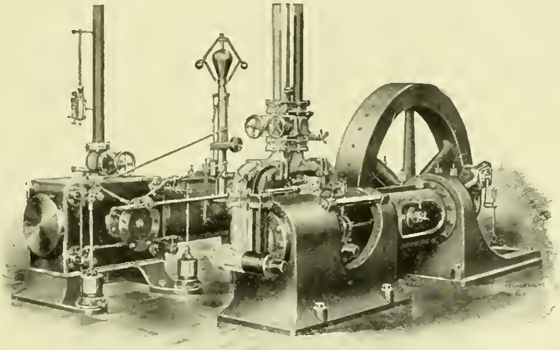
Send for list of residence installations. Send for list of steamships equipped with "BRUNSWICK" plants, or for general list of installations of all kinds.

The "BRUNSWICK" motto is not "Build the cheapest machine," but "Build the best." Our specialty is the small unit.

THE HUETTEMAN & CRAMER CO.

DETROIT, MICH.

REFRIGERATING AND ICE MAKING MACHINERY



The "Safety" Ammonia Compressor

FEATURES OF ADVANTAGE OF THE "SAFETY" REFRIGERATING MACHINE

This machine is designed to minimize the possibility of wreck or damage caused by a valve part or by liquid becoming imprisoned between cylinder and piston.

Due to the peculiar location of the compressor suction and discharge valves it is impossible for any valve part in case of breakage to enter the cylinder, and any shot of liquid that may come through the suction pipe will be forced out through the discharge valves, before the piston reaches the end of its stroke.

The machine is designed along the most improved and up-to-date lines, being of heavy duty construction throughout, and on account of being built horizontal it can be readily looked after and adjusted; also because of being made in sections, which in addition eliminates undue strains that exist in all large castings, it will permit of being installed in close quarters and in out of the way locations.

All working parts are provided with large wearing surfaces, every means of adjustment is provided, all these being readily accessible, and improved oiling devices are fitted to all wearing surfaces.

Because of its simplicity, accessibility and ready adjustment, it can be placed in charge of any average engineer with best results.

These machines are built for direct connection with engine or to be belt driven.

CAPACITIES IN TONS OF REFRIGERATION SIZES APPROXIMATE SPEEDS AND POWER REQUIRED

Tons Cap...	6½	8	9	11½	15	25	30	40	45	50	60	65	80	90	100	115	145	160
Bore........	5½	6¼	6	7	8	9	10	11	11½	12	13	13½	14	15	16	17	18	19
Stroke.....	12	12	14	14	16	18	20	22	22	24	26	26	30	30	32	32	36	36
R.P.M.....	90	90	85	85	80	80	75	75	75	70	70	70	65	65	60	60	60	60
Appr. H.P..	10	14	15	18	25	40	45	60	65	75	90	100	120	135	150	175	220	240

ALPHABETICAL INDEX TO CONDENSED CATALOGUES OF POWER PLANT EQUIPMENT

ALPHABETICAL INDEX TO DISPLAY ADVERTISEMENTS AND DIRECTORY CARDS

THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS

THE JOURNAL

VOLUME 34

NEW YORK
PUBLISHED BY THE SOCIETY
29 West 39th Street
1912

INDEX TO THE JOURNAL

THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS

JANUARY–JUNE 1912

INDEX TO THE JOURNAL, JANUARY-JUNE 1912

NOTE: Items appearing in The Journal as Society Affairs, have the month and page number given. Where the list of discussors of a paper is given, the list appears under the straight title of the paper. Papers published in The Journal previous to January, discussion of which was published during January to June, are indicated by the month, followed by 1911. All papers, reports, etc., of the Gas Power Section appear under the heading Gas Power Section. Items regarding Student Branches are so indexed. Miscellaneous items are indexed under Miscellaneous.

THE JOURNAL

of

THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS

JULY 1912

35 CENTS A COPY $3 A YEAR

ANNUAL MEETING: NEW YORK, DECEMBER 3-6

PERSONAL EFFORTS OF ALL MEMBERS NEEDED TO EXTEND THE USEFULNESS OF THE SOCIETY

A member writing to the Secretary said recently, "*Service to the community must be the basis of our future extension and growth.*" This truth has long been realized by the Society and finds an important expression in the work of ten industrial committees now preparing to hold sessions at the Annual Meeting in December next.

In order that these special sessions shall develop results of the greatest value it is necessary that the largest possible number of leading engineers and captains of industry in each of the lines enumerated shall be present to take part in discussing the papers presented.

Although recent efforts to strengthen the membership of the Society along these lines have been attended with gratifying success, there are still many eminent men whose coöperation is needed, and who are not yet members. The aid of these men can only be secured by personal effort on the part of members.

The policy of the Society in admitting to membership only men of attainments naturally precludes indiscriminate circularizing for new members, but every member should speak to those among his acquaintances whose coöperation in our work is desirable, and also notify the Society of his name and address so that suitable literature may be sent.

APPLICATIONS FOR MEMBERSHIP SHOULD BE FILED AT ONCE

Applications for membership must be filed by September 1 if they are to be acted upon at the December Meeting. As there is always delay during the summer in getting into touch with references, no time should be lost in forwarding names and answering letters when named as a reference.

COMMITTEE ON INCREASE OF MEMBERSHIP

I. E. Moultrop, *Chmn.*
C. W. Aiken
R. S. Allyn
R. M. Dixon
W. T. Donnelly
J. P. Ilsley
E. B. Katte
H. S. Wynkoop

JULY 1912 VOL 34 No. 7

THE JOURNAL

OF

THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS

PUBLICATION OFFICE, 29 WEST 39TH STREET . . . NEW YORK

CONTENTS

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The Society as a body is not responsible for the statements of facts or opinions advanced in papers or discussions. C55.

THE JOURNAL

OF

THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS

VOL 34 JULY 1912 NUMBER 7

THE SPRING MEETING

The Spring Meeting was held at Cleveland, Ohio, May 28 to 31, with a total registration of 562, of whom 221 were members. The headquarters during the meeting were at the Chamber of Commerce Building, where the professional sessions and several of the social functions were held, and lunches were served there on Wednesday and Friday. This building is well adapted for a gathering of this kind, and especially so in this case, as it is the home of the Cleveland Engineering Society, whose rooms were freely thrown open to the use of the members.

The Committee on Meetings, Dr. Charles E. Lucke, Chairman, had arranged a strong professional program, and the Local Committee under the chairmanship of Ambrose Swasey contributed in every possible way to the pleasure of the members and their guests. His efforts were ably seconded by those of Prof. Robert H. Fernald, Vice-Chairman, F. W. Ballard, Secretary, and R. B. Sheridan, Treasurer. The Local Committee was divided into several special committees, the Citizens Committee being headed by Mr. Swasey, the Executive and Entertainment Committees by Professor Fernald, and the Finance Committee by Mr. Sheridan, Transportation by George E. Merryweather, and Accommodations by Arthur G. McKee. The chairman of the Ladies Committee was Mrs. Ambrose Swasey,

and the Vice-Chairman, Mrs. Robert H. Fernald. At the Friday morning session resolutions were passed expressing the thanks and appreciation of the visiting members for their entertainment, but a word more should be added here on behalf of the Secretary of the Society and the office staff, whose work was greatly facilitated by the effective organization of the Cleveland committees. Not only was the abundant and enjoyable entertainment provided for, but their painstaking care in attending to the minor details connected with the management of the meeting was an important factor in its success.

THE FIRST DAY OF THE MEETING

On the afternoon of Tuesday, the first registration day, Mr. and Mrs. Ambrose Swasey received the members and guests at their residence. This gathering, held under auspices so favorable and surroundings so attractive, afforded a most pleasing introduction to the events that were to follow.

Tuesday evening was of the nature of a diversion from the more serious technical sessions of the succeeding days. Cleveland boasts one of the most skillful cartoonists in the country, J. H. Donahey of the *Cleveland Plain Dealer*, whose services were enlisted for the evening. Mr. Donahey is also a "lightning" sketch artist, and he made a series of crayon sketches before the audience on large sheets of paper. Several of these were caricatures of well-known people, and likenesses were drawn of President Humphreys, Ambrose Swasey, and Secretary Rice. Mr. Donahey had as running-mate the city editor of the *Plain Dealer*, W. R. Rose, who entertained the audience with stories while the sketches were in process.

ADDRESSES OF WELCOME

The session on Wednesday morning opened with a greeting by Mr. Swasey on behalf of himself as a member and as chairman of the local committee, and of the Cleveland members generally. He recalled that it was 29 years ago when the Society last met in Cleveland—a long time to wait for a second visit. The Society then numbered about 400 members, while today it has more than 4000. Not only has it grown in membership, but it has broadened its scope in every direction of mechanical engineering, covering new fields of science which were scarcely dreamed of when the Society met before in this city.

Many members would have gladly attended this convention, who,

for one reason or another, were unable to do so. Mr. Swasey had with him several letters sent to the local committee by absent members and read abstracts from some of the letters which came from past-presidents of the Society. One was from John E. Sweet, "the father of The American Society of Mechanical Engineers," who, said the speaker, should he live until October 21, would be 80 years of age; but "we know him to be of good courage, for on the day when he was 79, he and Mrs. Sweet started on a journey around the world, which was completed successfully."

Another letter was from E. D. Leavitt, who was president of the Society when it met in Cleveland 29 years ago. Still another was from John Fritz, whom they love to call "Dear old Uncle John," and who on August 21 next will be 90 years of age.

There were present on the platform at this opening session past-presidents George Westinghouse, E. D. Meier, Ambrose Swasey, S. T. Wellman and Jesse Smith, besides President Humphreys, and herewith are given extracts from letters received from other past-presidents who were unable to be present.

John E. Sweet wrote that he was not well, but that "the doctor has guessed at the right remedy. The idea of getting the past-presidents together is a nice thought, and I hope they will all be there except your humble servant."

E. D. Leavitt: "Eight years of continuous ill health precludes attendance at conventions and compels a quiet life. Please give my heartiest greetings to the members."

Henry R. Towne: "Permit me to compliment the local committee on its wisdom in planning to secure the attendance of as many as possible of the past-presidents. I had some share in initiating the plan under which the past-presidents become members of the council, and have always believed that the Society was greatly benefited and strengthened by thus retaining the influence and council of those who have served it in a presidential capacity."

John R. Freeman: "I have extremely pleasant memories of Cleveland dating away back to the first meeting of our Society in your city, and to an exhibition of an observatory live ring at the then modest shops of Warner and Swasey."

Oberlin Smith: "Heartiest greetings to the members of our beloved Society; would I were there."

John Fritz, who at present is confined to his room through ill health, expressed the wish that he could again meet the members of the various engineering societies with whom he has been so intimately associated for so many years, and asked through his Secretary "that his kindest greetings be extended to all dear friends assembled."

Fred. R. Hutton: "I send this greeting and sentiment based on the initials of the Society's name. May the initials A. S. M. E. stand also in the future as in the past for organization Always Sane, Majestic, Energetic.

"*Always*, with a permanence of wise policy in its management; *Sane*, undisturbed by fevers and the delirium of the newest untried dope of the demagogue;

Majestic, because, conscious of its power and its responsibility, its stored energy is irresistible; *Energetic*, because it is always moving in progress toward its goal of pre-eminence."

Notes of regret were also received from Past-Presidents Charles E. Billings, James M. Dodge and M. L. Holman.

Mr. Swasey then introduced Newton D. Baker, mayor of Cleveland.

ADDRESS OF MAYOR BAKER

Newton D. Baker, mayor of Cleveland, on behalf of the City, welcomed the Society in an address which was a model of its kind. He said in part that he could well understand the surprised inquiry of an ancient population when they asked, "Is Saul among the prophets?" for he discovered himself in an attitude which was certainly as unfamiliar as prophecy could have been to Saul. The idea of a mayor being in the company of so many eminent and distinguished engineers presented an anomaly that nothing but the accidents of political fortune could possibly explain. Perhaps, however, since the profession to which engineers devoted their lives was the business of directing the energy of and producing results from machinery, it was not so wholly inappropriate that a man who occasionally dipped into political endeavor should be among them, and yet he hardly deemed himself worthy on that ground alone to be a member of that distinguished company.

In commenting on a statement attributed to Dr. Humphreys, that the age of the poor genius had passed, that the geniuses of the future were going to be rich, he said he was enabled to congratulate them all heartily, but that it did not afford him any particular personal satisfaction.

Engineers represent one of the greatest departments of human knowledge and human endeavor. The mapping out of the activities of mankind that has gone on in the last hundred years, the last fifty years even more markedly, has set aside out of the great domain which the human intellect could hope to conquer, special provinces for special men. But in the mechanical arts, the application of the great forces of nature to machinery, the advance has been the wonder of the world. The only aspect that occurred to him as appropriate for him to consider or to suggest for the consideration of those present was whether or not the economic aspects of their activities have really been as progressive as the scientific and mechanical aspects; has the benefit that ought to have come to the human race

from these marvellous inventions and this increased knowledge been as widespread as it ought to be? He felt that unless the economic aspects, the processes of distribution, the economic aspects of the advance of mankind keep pace with the conquering hand that reduces the forces of nature to better subjection, an unstable civilization will result.

He took a very solid satisfaction from the statement that the poor genius is a thing of the past; because it seemed to him that the man who had the genius to conceive and fabricate the wonderfully interesting and complicated and intricate and wonderfully productive things that were now made in response to the suggestion and the touch of men like those present, men who had the genius to do that, if they are to be the participants in the benefits, if they are really to be controllers of the economic process as well as of the mechanical and industrial process, it will mean a wider distribution of the benefits of this advance of learning.

In concluding he said it was no part of his habit, no part of his taste to praise Cleveland, but he as mayor, in welcoming the Society, wished to characterize the thing of Cleveland which most appealed to those that lived there and of which they were most proud, and of which he wanted the Society to be the most conscious as Cleveland's message to it on its departure. He thought he could truthfully say that the general attitude of the people of Cleveland was a certain hospitality to new ideas, a certain generosity in its welcome to every man who comes to it with a message, to every man who comes to it bringing wisdom, to every man who comes to consult and confer for things that better the human race.

DR. HUMPHREYS' REPLY

In his reply, Dr. Humphreys was sorry to confess that he was not responsible for the statement attributed to him, but wished he had said it now that it had been turned so beautifully. He was delighted to have heard Mayor Baker speak as he did with regard to what he conceived to be the outlook of the engineer, for he had touched on a topic which was very close to his heart. He thought that the real growth of the Society was to be found, not in the increase in numbers, but in its growth in character and scope.

So many of the problems of the day which are troubling us in this country, and even threatening us, have to do with industrial problems, and certainly if there is any body of men that can help toward the solution of those problems it must be the educated engineers of

the United States. He agreed that they as a profession had not recognized that responsibility and that the day had come when they must recognize that they were not only engineers, but that they were citizens, and as such, carry a very great responsibility in connection with their citizenship because of the knowledge they have in regard to engineering matters, and consequently of industrial problems. For these reasons he considered that the politician and the engineer could not afford to work apart.

This ended the introductory remarks and the meeting proceeded to the order of business, President Humphreys presiding, the first item being the announcement by the Secretary of the reports of the Tellers, first on the recent vote on the amendment to the constitution, relating to the expenses of meetings and second on the election and promotion of members.

The amendment is as follows, which is to be inserted between the existing C 42 and C 43 of the constitution:

C 43 The expenses of all meetings of the Society and of any group or section thereof, shall be arranged in accordance with such By-Laws and Rules as the Council may from time to time adopt, provided, however, that nothing in this section shall be construed to authorize the Council to make any increase in the annual dues of members in any grade.

The summary of the membership ballot is as follows:

SUMMARY OF BALLOT

Members	196
Promotion to Members	37
Associates	5
Promotion to Associates	1
Juniors	125
Total	364

Jesse M. Smith, Past-President, at the request of the Council, then presented a report on several proposed amendments to the constitution. These amendments were suggested by the Committee on Increase of Membership and the Membership Committee to better provide for new members and make our Society uniform in its membership and method of election with sister engineering societies here and abroad. A new grade of membership is proposed to be known as Associate-Member, which is distinguished from the present Associate grade. As defined an Associate "shall be thirty years of age or over. He need not be an engineer, but must have been so connected with some branch of engineering or science

or the arts or industries that the Council will consider him qualified to coöperate with engineers in the advancement of professional knowledge." An Associate-Member "shall be an engineer or teacher of applied science of twenty-five years of age or over. He must show by his experience or by his duties that he is competent to execute work in his profession." It is further proposed to simplify the machinery of election of members by submission of the ballot to the Council only instead of to the membership at large.

In the discussion of this report, A. B. Carhart raised the point that confusion might result from having two grades of membership with names so nearly alike as the ones proposed of Associate and Associate-Member. Charles Whiting Baker believed there was serious objection to the proposal and suggested that the difficulty might be overcome by following the plan of some of the foreign societies, calling the youngest grade of members Student-Members, consisting of those from 21 to 25 years of age, and then adopting the term Junior-Member for the man between 25 and 30 who wants to come into the Society.

The full text of the proposed changes in the constitution will be submitted to the membership in letter-form 60 days before the December Annual Meeting for discussion at that time.

PROFESSIONAL SESSIONS

Following the business meeting came the first of the professional sessions, one being a continuation of the business meeting in the main auditorium and the other a meeting of the Gas Power Section, held in the Chamber of Commerce library. All the professional sessions were of interest, holding the attention of the audiences throughout, and were well attended.

In connection with this account is published a complete program of these sessions together with a list of those who took part in the discussion. Abstracts of the several papers with a complete report of the discussion will appear in later issues of The Journal. The papers themselves have already been published in The Journal in full.

WEDNESDAY AFTERNOON AND EVENING

On Wednesday afternoon there were definitely arranged eight excursions, as follows: American Steel & Wire Company, by special

train; Brown Hoisting Machinery Company; National Acme Manufacturing Company; Peerless Motor Company; Pennsylvania Railroad Ore Handling Plant; Warner and Swasey Company; White Company (automobiles); Winton Motor Carriage Company.

Everybody, both ladies and gentlemen, were further invited to the Cleveland Country Club, where tea was served. Many accepted and the trip was made by automobile in cars supplied by the Winton, Peerless and White companies. The drive to the Country Club takes one over several miles of the park system of Cleveland and is a delightful trip.

On Wednesday evening, Dr. Dayton C. Miller of Case School gave his lecture on Sound Waves. After the lecture expressions of commendation were heard on every hand. Dr. Miller's exposition of the subject was clear and clean cut and his demonstration of apparatus and slides thrown on the screen showing the characteristics of sound waves were of exceptional interest. An abstract of the lecture, given quite fully, is published elsewhere in this number.

THURSDAY'S ENTERTAINMENT

On Thursday the morning session adjourned at 11:30 in order to give everyone an opportunity to go on the afternoon excursion on Lake Erie by one of the boats of the Eastland Navigation Company. The boat was entirely at the disposal of the members and guests and the sail on the lake was most enjoyable and gave what was perhaps the best opportunity of the convention for meeting friends and renewing acquaintance.

On Thursday evening, the local members were at home at the Colonial Club where the visiting members and friends were received, and later in the evening there was the dance and collation which have regularly been enjoyable features both of the Annual and Spring Meetings.

FRIDAY'S EVENTS

The visiting members very generally stayed over until Friday evening, attending the session in the morning and the excursions in the afternoon. In fact, the Friday morning session brought out the most varied and interesting discussion of the entire meeting.

The excursion planned for the afternoon was by train to Akron, Ohio, where visits were made to the plants of the Goodrich Rubber Company and the Wellman-Seaver-Morgan Company.

At the conclusion of the discussion of papers on Friday morning, Prof. Arthur M. Greene offered the following resolution:

Whereas, the members and guests of The American Society of Mechanical Engineers assembled at the Semi-Annual Meeting in Cleveland, Ohio, May 28-31, 1912, have received the generous hospitality of the members of the Society in Cleveland and its vicinity, and have participated in the many social events arranged by the Local Committee:

Be It Resolved, that on behalf of the visiting members and guests the Secretary extend the thanks of the Society to the Local Committee and to the Ladies Committee for the many provisions made for their pleasure and comfort in Cleveland; to Ambrose Swasey, Past-President, and Mrs. Swasey for the delightful reception in their home; to Messrs. J. W. Donahey and W. R. Rose of The Cleveland Plain Dealer, for their entertainment; to Dr. Dayton C. Miller of the Case School of Applied Science, for his instructive lecture on Sound Waves and the demonstration of the new instrument, the "Phonodeik"; to J. D. Rockefeller for opening his spacious and beautiful grounds; to the Cleveland Engineering Society for the use of their rooms; to the Cleveland Telephone Company for gratuitous service rendered; to the White, Peerless and Winton Automobile Companies for cars placed at the disposal of the visitors; and to the American Steel & Wire Company, the B. F. Goodrich Company, the Wellman-Seaver-Morgan Company, the Warner & Swasey Company, and other firms in Cleveland and vicinity, who generously opened their works for inspection by those in attendance at the Convention, or in certain cases supplied means of transportation and entertainment.

Past-President E. D. Meier then said that any resolution of this kind must necessarily be put into such short form that it seems almost perfunctory and that there was no one who had participated in the hospitality extended by the Cleveland friends but would feel that more was meant than the resolution actually said. "The expression of appreciation comes from our hearts; those who have had the pleasure of attending other conventions at Cleveland were prepared to expect a great deal, but their expectation has been outdone." He could only say that he hoped that at the Annual Meeting in New York as many Clevelanders as possible would honor the members there and give them a chance to reciprocate in a small way. Colonel Meier seconded the motion and suggested that it be adopted by a rising vote.

Secretary Rice expressed his thanks because, as he said, he had "had absolutely nothing to do, and such an opportunity is seldom given to a Secretary." It is always the aim at these conventions to have the ideal combination of a great variety of subjects presented by the best authorities in order to extend the scope and thought of every man and to give him an incentive; and then to provide in addition for the development of social acquaintanceship, all tending

to the greatest good of the profession. The latter part, the development of social acquaintanceship, had been magnificently provided for by the Cleveland members, and he wished to express every possible appreciation for the splendid work which Mr. Swasey and the Local Committee had accomplished.

The resolution was then passed unanimously and briefly acknowledged by Mr. Swasey for the Local Committee.

ENTERTAINMENT BY THE LADIES COMMITTEE

Through arrangements made by the Ladies Committee, the visiting ladies were invited to see as many points of interest about the city as their time allowed. On Wednesday morning they visited the plant of the H. Black Company, Cloak manufacturers, where processes of manufacture were inspected and garments were displayed on the company's models. Beside the trip by automobile to the Country Club, the ladies were taken through the spacious grounds of J. D. Rockefeller by automobile.

PRINTED MATTER

The printed matter issued by the Cleveland committee was exceptionally attractive and complete. A handsome souvenir of the Convention is "The Cleveland Book," containing 125 pages, bound in flexible cloth and printed on coated paper, with many illustrations. To quote the words of the title page, it contains "the program and particulars of the event together with an account of the leading participants in present and past meetings of the Society in Cleveland, and some discussion of the civic and manufacturing details that are of most consequence to mechanical engineers." No less than five past-presidents of the Society have been active in the affairs of Cleveland, and an account of their lives is given in the book. There is also much information about Cleveland and its various institutions.

A convenient vest-pocket booklet was issued containing a directory of plants with a description of the street car routes and time schedules in order to give visitors all possible aid in making the best use of their time during their stay in the city. A small map of the business section of Cleveland is included in this booklet.

An innovation in the way of printed matter was the issuance each day of the "A.S.M.E. Daily News," consisting of slips of cardboard of pocket size on which were printed a list of the events for the day and the hours at which they were to occur; including the professional sessions, entertainment features, excursions, etc. These slips were

a great convenience to the visitors and constituted a feature which may well be adopted at later meetings.

PROGRAM

OPENING SESSION

Tuesday Afternoon, May 28

Informal reception at the home of Mr. and Mrs. Swasey.

Tuesday Evening

Membership reunion and informal reception, Chamber of Commerce Hall.

SECOND SESSION

Wednesday Morning, May 29

Business Meeting: Reports of committees, tellers of election; new business.

A New Analysis of the Cylinder Performance of Reciprocating Engines, J. Paul Clayton.

Discussed by Arthur L. Rice, F. E. Cardullo, R. C. Stevens, S. A. Moss, R. C. H. Heck, F. W. Marquis, C. D. Young, J. B. Stanwood, W. D. Ennis.

Equipment of a Modern Flour Mill on a Gradual Reduction System, John F. Harrison and W. W. Nichols.

Design and Mechanical Features of the California Gold Dredge, Robert E. Cranston.

SIMULTANEOUS SESSION

GAS POWER SECTION

Problems in Natural Gas Engineering, Thomas R. Weymouth.

Bituminous Coal Producers for Power, C. M. Garland.

Discussed by O. P. Hood, E. D. Dreyfus, Leon B. Lent, N. A. Marsh, Thos. R. Weymouth, Chas. W. Baker.

Some Tests on Carbureters, George W. Munro.

Discussed by Mr. King, C. M. Garland, Professor Vose, R. C. Carpenter, George A. Orrok.

Wednesday Afternoon

Inspection by members of local manufacturing and power plants. Automobile trip for ladies through the parks. Tea served at the Country Club.

Wednesday Evening

Sound Waves: How to Photograph Them and What They Mean, Dr. Dayton C. Miller, of the Case School of Applied Science.

THIRD SESSION

Thursday Morning, May 30

New Processes for Chilling Cast Iron, Thos. D. West.

Tests of Chillable Irons, Thos. D. West.

Discussed by J. E. Johnson, Jr., H. M. Lane, Benjamin D. Fuller, Henry M. Howe, Henry Souther, P. Munnoch, Paul Kreuzpointner, James A. Beckett, Carl Hering, A. S. Dowler, C. B. Murray, Albert Sauveur, Bradley Stoughton, A. E. Outerbridge, Jr.

Strength of Steel Tubes, Pipes and Cylinders under Internal Fluid Pressure, Reid T. Stewart.

Discussed by C. N. Sames, T. A. Marsh.

On the Control of Surges in Water Conduits, Wm. F. Durand.

Speed Regulation in Hydroelectric Plants, Wm. F. Uhl.

Thursday Afternoon

Excursion on Lake Erie.

Thursday Evening

Reception and dance at Colonial Club.

FOURTH SESSION

Friday Morning, May 31

The Present State of Development of Large Steam Turbines, A. G. Christie.

Discussed by George A. Orrok, F. Hodgkinson, C. V. Kerr, J. A. Moyer, Clarence P. Crissey, E. D. Dreyfus, Carl Geo. deLaval, W. L. R. Emmet.

A Discussion of Certain Thermal Properties of Steam, G. A. Goodenough.

Discussed by F. E. Cardullo, H. N. Davis, R. C. H. Heck.

The Reduction in Temperature of Condensing Water Reservoirs due to Cooling Effect of Air and Evaporation, W. B. Ruggles.

Discussed by F. E. Cardullo, W. H. Carrier, W. T. Donnelly.

Results of Tests on the Discharge Capacity of Safety Valves, E. F. Miller and A. B. Carhart.

Friday Afternoon

Inspection of plants of The Goodrich Rubber Company, the Wellman-Seaver-Morgan Company at Akron, and the Diamond Match Company at Barberton.

SOUND WAVES

WHAT THEY MEAN AND HOW TO PHOTOGRAPH THEM

On Wednesday evening of the Spring Meeting an exceedingly interesting experimental lecture was given by Dr. Dayton C. Miller, professor of physics in Case School of Applied Science, on the subject of sound waves. The lecture culminated in the demonstration of an instrument invented by the speaker, known as the "phonodeik," by which the characteristics of sound waves are recorded on a photographic film. Many of these records were projected on the screen, and a demonstration was given of a large projection phonodeik by which a ray of light, reflected from a mirror caused to vibrate by sounds from various sources, is thrown on the screen in a way to show the characteristics of the sound waves produced.

In the production of sound the vibrations of the sounding body are transmitted to the ear, usually through the medium of the atmosphere. These vibrations produce in the surrounding air displacements, velocities, accelerations, changes of density, and other physical phenomena. These changes of density and other phenomena are propagated outwards in radial directions, with a velocity of about 1100 ft. per sec. Such disturbances as they exist in the air around a sounding body, constitute *sound waves*.

The only kind of vibration that can be propagated by the air is a longitudinal, or back-and-forth, movement as distinguished from a cross-wise or transverse movement. All that the ear perceives in the complex music of a symphony orchestra is contained in the wave-motion of the air which is completely represented by motion of one dimension, that is by motion in a straight line.

That motion in one dimension is capable of producing such sounds is simply proved by the telephone, the diaphragm of which can move only back-and-forth. The talking-machine is perhaps a better demonstration of the same fact.

The ear receives three classes of sensations from tones, and presumably no more. One of these gives rise to the characteristic of

the tone called pitch; this is easily proved to depend upon a very simple condition, that of mere frequency of vibration.

The second property of tone is loudness or intensity, which is not so simple as pitch. For tones of the same pitch, it varies mainly as the energy of vibration, and this is a function of the amplitude, varying approximately as its square; loudness also varies with pitch, approximately as the square of the frequency.

The third property of tone is much the most complicated; it is that characteristic of sounds produced from some particular instrument or voice, by which they are distinguished from the sounds of the same loudness and pitch, produced from other instruments or voices. This characteristic is called timbre, tone-color, or simply, *quality*.

When we inquire as to the cause of tone quality, since pitch depends upon frequency and loudness upon amplitude, we conclude that quality must depend upon the only remaining property of a periodic vibration, namely, the peculiar kind or form of the motion; or, if we represent the vibration by a curve or wave line, the quality is dependent upon the peculiarities represented by the shape of the wave. There is possible an endless variety of motion for the production of sound, and quality is, therefore, almost infinitely complicated in its causes, as compared with the other two properties of sounds.

As already stated, sound waves in air are longitudinal; in many solid bodies the motion producing and transmitting sound are transverse, as in the tuning-fork. It can readily be shown that both kinds of wave motion are correctly and adequately represented by the same type of line, the *harmonic curve*. The correctness of this statement is also shown by the talking-machine, the record for which is a *transverse* wavy line, which by the reproducing mechanism gives equivalent *longitudinal* movements to the diaphragm.

Tuning-forks properly constructed and mounted on resonance boxes are shown by analysis to produce vibrations in the air which are single simple harmonic motions; the resulting tones are called simple tones, and their sensation is markedly simple and pure. If several simple tones of different pitches, as from several tuning-forks, are simultaneously sounded, they simultaneously excite different systems of waves, which exist as variations in density of the air; the resulting displacements, velocities, and changes in density of the air are each equal to the algebraic sum of the corresponding displacements, velocities, and changes in density which each system

of waves would have separately produced had it acted independently. There must, therefore, be peculiarities in the motion of a single particle of air which differ for a single tone and for a combination of tones; and in fact the kind of motion during one period is entirely arbitrary, and may indeed be infinitely various. (A model was exhibited showing three simple waves, and their combinations in various phases.)

Every sound which has a distinct quality is a composite sound. Analysis has shown that the tone from a clarinet may have twenty-five or more components, the trombone thirty, and the piano as many as forty-two. Such tones are musically rich and full in quality and are usually much admired; though by way of contrast, simple tones are often considered very sweet. (An experiment was performed, compounding ten simple tones into one resultant tone, illustrating the composite character of the ideal musical tone.)

The method by which the ear proceeds in its analysis of tone quality was first definitely stated by Ohm, in Ohm's law of acoustics. Helmholtz states this law in the following form:

"Every motion of the air which corresponds to a composite mass of musical tones is capable of being analyzed into a sum of simple pendular vibrations, and to each such simple vibration corresponds a simple tone, sensible to the ear, and having a pitch determined by the periodic time of the corresponding motion of the air."

Fourier proved, in 1822, in a purely mathematical way, and with no idea of acoustical application, that any given regular periodic function, such as the most complex sound wave, can always be represented by a trigonometric series of sines and cosines, and for each case in one single way only. Each sine or cosine term in the series may be considered as representing a single simple component wave; then in Fourier's series, the successive terms have frequencies which are exact multiples of the first, but the amplitudes and phase differences are arbitrary and can always be found in every given case, by peculiar methods of calculation which Fourier has shown.

If the Fourier series corresponding to a given wave is determined, the wave is said to have been analyzed. The series may be written in the form of an equation for the mathematician, or it may be shown graphically for the physicist. (Charts and slides were shown illustrating the analysis of curves, and showing a harmonic analyzer, which is a kind of mechanical integrating device, and may be used with great convenience; it is only necessary to trace the curve with

a pointer attached to the recording device, and then to read from a series of dials the numerical data which determine the separate simple components of the complex wave. A harmonic synthesizer was also illustrated.)

In order that sound waves may be analyzed in accordance with the principles stated by Ohm and Fourier, it is necessary to have a record of the sound wave, that is, to have a curve which corresponds to the peculiar motions of a particle transmitting the sound. The most successful instruments that have been used for this purpose are the manometric flame, the telephone, the phonautograph, and the talking machine.

None of these methods seemed adequate for proposed investigations; and after several years' experimenting an apparatus has been developed which gives accurate records showing great detail. The instrument has been named the "phonodeik," meaning to show sound.

The sound to be recorded is concentrated by a horn upon a diaphragm; the motion of the diaphragm is communicated to a minute mirror. Light from the electric arc falls upon the mirror and is reflected to a moving photographic film in a special camera, producing the record of the sound waves. A magnification of about 2500 is commonly employed; the film moves at the rate of from five to fifty feet per second, and in some cases the spot of light has a velocity on the film of 1000 feet per second. The vibrator employed in making the photographs is very minute, the mirror being about 0.04 inch square, and the whole weighing about a thirty-second part of a grain. For purposes of demonstration a larger phonodeik has been made, which will exhibit the principal features of "living sound waves," so that a thousand people can see them. (A demonstration was made with the projection phonodeik, showing the sound waves from many sources and from the voice of the speaker during the concluding part of the lecture.)

The methods described are being used in an elaborate study of the nature of sounds from various sources, the results of which may be presented at some future time.

GENERAL NOTES

TWELFTH INTERNATIONAL CONGRESS OF NAVIGATION

The Twelfth International Congress of Navigation convened in Philadelphia, May 23, and was attended by considerably over 300 foreign delegates. A committee of our Society consisting of Charles Whiting Baker, Chairman, W. M. McFarland, H. deB. Parsons, George B. Massey, Stevenson Taylor, John W. Lieb, Jr., and Jesse M. Smith, augmented by T. C. Martin, E. E. Olcott, E. L. Corthell, met each delegate and welcomed him as he arrived in America. A special invitation was personally addressed to each and handed to him on the steamer, inviting him to make his headquarters at the Society's house and to use it to its fullest extent while in America. The official delegate to the congress was Wm. T. Donnelly.

The congress was opened by the President of the United States and by state and municipal representatives, and continued four days. The banquet on the last day was probably attended by the greatest number of engineers of any banquet held in the United States. At the conclusion of the meetings in Philadelphia professional visits were arranged as follows: one section went to Boston to view the Cape Cod Canal, and other sections went to Pittsburgh, to Washington and to New York. In New York the visitors were officially received by the City of New York and shown, under the guidance of Calvin Tomkins, commissioner of docks, the harbor and dock facilities. There was a reception at the rooms of the American Society of Civil Engineers and visits to the tunnels now under construction. Then followed a daylight trip up the Hudson to Albany where the engineers who had gone to Boston were joined and the whole party continued on a trip through the Great Lakes.

1912 FLANGE STANDARD

The 1912 Standard for Extra Heavy Flanges and Flanged Fittings, having reference mainly to sizes above 8 in. in diameter and ordered printed by the Council in the February Journal, was the result of

labors covering a period of considerably over a year by the committee consisting of Messrs. H. G. Stott, Chairman, A. C. Ashton, W. Schwanhausser, J. P. Sparrow and W. M. McFarland, acting in an advisory capacity to the National Association of Master Steam and Hot Water Fitters. This standard has been adopted by the Bureau of Standards and several of the other departments of the United States, and pipes and fittings made according to it may be secured from many firms, notwithstanding it has been in effect only since May 1.

Pipes and fittings made according to the 1912 standard are considerably heavier and stronger than those made according to the manufacturers' alternative standard or the standard adopted in 1904 by the Engineering Standards Committee of Great Britain, or the one adopted in 1900 by the Verein deutscher Ingenieure. In the report last year of the Alsace Association of Owners of Steam Machinery Plants is the statement that there have been a great many accidents in joints of pipes and valves made according to the last standard which had resulted in fatal consequences and that there was general dissatisfaction, all of which confirms the judgment of the Society's committee in increasing the strength of flanges where the initial mechanical strains of construction are often several times that due to the steam pressure.

In general the 1912 standard is intended for plants where no sum is considered too great which will ensure safety and continuity of service.

SUB-COMMITTEES OF THE COMMITTEE ON MEETINGS

Six additional sub-committees of the Committee on Meetings have been appointed as follows: Iron and Steel, Air Machinery, Railroad Equipment, Industrial Building, Hoisting and Conveying, Fire Protection. It is expected that papers and reports in the field of engineering covered by these committees will be presented during the coming year. Information will be of service and suggestions will be gratefully received from members having original material to offer in any of the lines of activity coming within the scope of these committees.

Attention has already been called to the fact that it is desired to have papers for the Annual Meeting on hand by September 1.

LOCAL MEETINGS

At the convention in Cleveland representatives from six cities met in conference and recommended the form of meetings which the Society should conduct in the several cities. This form was later adopted by the Council.

The substance of the method adopted is that local meetings be considered as sectional meetings with the local committee in responsible charge, and that the By-Laws and Rules of the Society now in vogue for professional meetings be applicable to the geographical sections.

A close relation between the Society's activities and activities of the several centers is maintained by the interchange of papers and contributions from the Society's funds, for the professional features of the local meetings.

Additional local obligatory fees, as such, are not favored either by the centers or by the Council, all members of the Society being by right entitled to attend all meetings wherever held. This, however, does not make it impossible for voluntary contributions to be made for activities, professional or social, which may be conducted by the local committees.

Another feature of the recommendation from the conference emphasized by the Council is that sections should build up and strengthen local engineering interests and societies in a broad and general way, with the assistance and coöperation pledged in advance by the national Society.

The Council has been greatly interested for years in the holding of meetings in the several cities as best promoting the general interest of the members, but has refrained from formulating rules till experience has been obtained to enable a satisfactory code to be designed.

INVITATION TO MEET IN GERMANY, JUNE 23-25, 1913

The Society is just in receipt of the following cable:

American Society of Mechanical Engineers,
29 West 39th Street.

The Verein deutscher Ingenieure has today unanimously resolved to invite The American Society of Mechanical Engineers to its next Annual Meeting in Leipzig.

Oskar Von Miller, *President.*

Preliminary announcement is thus made of the invitation, which has been accepted by the Council to a joint meeting of this Society with the Verein deutscher Ingenieure in Leipzig in June next year.

A committee of arrangements will shortly be appointed and the Society can expect an extraordinary opportunity to hold a meeting with the national society of Germany and make an official tour of the industrial centers, concluding with a meeting in Munich and a visit to the German museum of which Dr. Von Miller is president.

AN ANALYSIS OF ACCIDENTS IN A MACHINE TOOL WORKS

By Luther D. Burlingame

ABSTRACT OF PAPER

The paper deals with an analysis of accidents in a machine tool works showing what proportion of accidents are due to each of a number of different causes; also an analysis as to which departments of the works have the greatest number of accidents and further as to the degree of disability resulting from the accidents. The purpose of the paper is to learn from past experience how to reduce accidents in the future.

AN ANALYSIS OF ACCIDENTS IN A MACHINE TOOL WORKS

By Luther D. Burlingame, Providence, R. I.

Member of the Society

In making a study of safety methods and safety devices, an analysis of the accidents that have occurred in one of our large machine shops may be of service for still further protecting the workmen when engaged in their various lines of employment.

2 A careful record of all accidents in the works of the Brown & Sharpe Manufacturing Company has been kept during the last seven years and a study made of them for the purpose of ascertaining where danger is greatest, what accidents are preventable and how best to avoid them. It may be said that in this factory extra care has been taken for many years to guard against accident and the management has never hesitated to spend money for that purpose when convinced that it would bring about safer conditions. During the last year an additional effort has been made to profit by past experience both at our own works and by the experience of others and still further to tune up the safety equipment and spirit of the organization in order that accidents might be reduced to a minimum.

3 When this additional work was undertaken, about a year ago, an analysis of all accidents which occurred during the previous six years was made along three lines: (*a*) the percentage of accidents under each of 18 headings from different causes; (*b*) the percentage by departments of the shop, divided into more than 30 groups; (*c*) the seriousness of the injury and the resulting length of disability from work. Following this, a similar record is being kept each year showing (*d*) what kinds of accidents are increasing and what kinds are being decreased by the further safety methods being adopted,

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Presented before the April 1912 Meeting of the Providence Association of Mechanical Engineers (Affiliated with The American Society of Mechanical Engineers).

also which departments are reducing their accidents and which are growing worse.

4 The different kinds of accidents were classified as follows, and the percentages given are for the six years preceding the date of the investigation, i. e., 1905 to 1910 inclusive:

	Total Accidents	Percentage
Caught in machinery	78	7
Caught or struck by belt	23	2
Set screw or other projection	29	2.6
Falling on or striking workman	226	20.1
Workman falling or strain lifting	75	6.7
Machinery starting unexpectedly	8	0.7
Chain or rope slipping or breaking	10	1.0
Punch press, rolls, or shears	20	2
Cutters and metal saws	94	8.5
Handling work or chips—eyes	126	11.2
Woodworking machinery	47	4.2
Burns, including electricity	79	7.0
Cuts with sharp instruments	20	2
Jams and hammer blows	71	6.3
Caught in tool and work (not cutters)	176	15.7
Elevator	4	0.5
Fooling	13	1.2
Litter or dark places	15	1.3

5 These accidents naturally divide into two groups: (1) those caused by machinery either (*a*) by being caught in the gearing, belting or other parts of the machinery, or (*b*) by being injured by the cutter or other tool or caught between the tool and the work; (2) those caused by falling, jams, burns, cuts, etc. The first group includes, 42.7 per cent of the accidents occurring during the six years, divided as follows: group (*a*) 12.3 per cent; group (*b*) 30.4 per cent. This leaves 57.3 per cent as the proportion of accidents occurring under the second group.

6 From the above analysis it will be seen that if complete guards could be provided so that every accident due to being caught in gearing, on set screws, or anywhere in the mechanism of machinery would be avoided, it could at most only reduce the accidents 12.3 per cent. Several recent occurrences show the unexpected accidents which result from this cause. A workman, hearing a rattling in the knee of a milling machine he was running, reached his hand underneath to see if the cause were due to a collar which he thought might have become loose, and stuck his finger into the running gearing.

7 Another case was that of a workman who reached for a can

of oil which he had left on a ledge of the machine. In lifting it up he caught a finger in the pump gears back of the guard. Both of these accidents occurred on machines considered sufficiently guarded, and to experienced workmen, indicate that to have complete safety it may be necessary to enclose all gearing entirely, whether or not it is exposed.

8 A way of preventing accidents by being caught by set screws or other projections, also coming under this division, is to insist on the wearing of short-sleeved jumpers, to avoid loose clothing, hanging neckties, etc. One of the apprentices at the Brown & Sharpe Manufacturing Company's works was injured recently by having the pocket of his jumper catch on the set screw of the revolving dog while he was filing. All of the boys running machines at this plant are obliged to wear short-sleeved jumpers and the men are advised to. Seventeen of the accidents reported were due to being caught by the sleeve of the jumpers.

9 The company is now experimenting with various forms of safety dogs, none with the projecting set screws having been added to the equipment during the last year. The plan of changing the regular dogs for headless screws adjusted with a socket wrench is also being tried experimentally.

10 The accidents in group (*b*) are more frequent and more difficult to guard against. It is practically impossible in many cases to do guarding at the point of cutting, and if guarding is attempted it may introduce dangers greater than those sought to be avoided. It is, however, possible to insist that the fingers shall never be used to wipe off chips, etc., from a running cutter. Out of the 94 accidents from cutters reported, 30 were caused by being caught when wiping off chips with the fingers.

11 In the use of punch presses 20 accidents had occurred in the period investigated, so this was one of the first matters to be considered. The means adopted for guarding against these accidents were novel, as far as the author is aware, and have proved fully successful both in avoiding accidents and in preventing an appreciable increase in cost of doing the work. A rule was made that the fingers and hands must never be put between the punch and die. Tweezers and pliers were furnished for handling the work, the points being shaped in some cases to suit particular jobs. The only accidents since have been to the points of the tweezers and pliers. Chutes have also been used to slide the work into position, a

stick being used to remove it after the operation. For some work which it was thought could not be handled by the above means, a swinging fixture was designed so that the work can be put in place away from under the punch and then swung into position for the operation.

12 The 47 accidents from woodworking machinery were largely cuts from circular saws, but included eight where the block of wood was thrown back when slitting, two of the cases being fatal, the only fatal accidents in the works during this period. The men are now required to wear a heavily padded apron when using a slitting saw, and this has, it is believed, saved the lives of several workmen. The use of a "spreader" when properly installed helps to prevent such accidents by keeping the cut from closing in back of the saw.

13 Another prolific source of accidents which, while not serious perhaps, are painful, is in being cut by revolving grinding wheels, especially when doing internal grinding and trying the plug in the hole without running the wheel back a sufficient distance. Twenty-eight of the accidents were from this cause. A shield has been designed which automatically swings up in front of the wheel so as to protect the hand if the plug should slip.

14 Under the second group, falling, jams, burns, cuts, etc., a large proportion of the accidents are entirely within the control of the workman, either the one hurt or a fellow workman, and the remedy is largely to be found by employing careful methods. In this, however, the foreman can exercise a large influence for safety. Some specific remedies can also be applied. It was found that 37 cases of burned feet in the foundry had resulted from wearing laced or low shoes. A rule was made that Congress or other high shoes without lacing should be worn, and a supply of such shoes is kept and sold to the foundrymen at about cost. This has nearly remedied the trouble. There remains, however, the liability of the iron spattering into the tops of the shoes and burning the legs when the pants are ragged. A study is being made of the possibility of using pants made of non-burnable material.

15 About one-fourth of all the accidents are caused by weights falling on the workman and jamming or cutting either the hands or the feet, and from the workman himself slipping and falling. The remedy here is to use care that safe methods are employed and that men do not take chances. Classified with these are 13 accidents traceable to "fooling," some occurring outside of working hours.

16 In considering the classification by departments and kinds of

work, it was found that, for the period of six years, the average number of accidents was greatest in the following departments, the percentage of employees injured each year being as follows:

(*a*) *Grinding department*, 13.8 per cent, being caused largely by cuts from grinding wheels. This has been much reduced during the past year, so that this department now ranks eighth instead of first in order of accidents.

(*b*) *Laborers*, 10.6 per cent, largely from injury by falling objects, jams, strains in lifting and the workman falling.

(*c*) *Carpenters*, 10 per cent, a large proportion of the injuries being due to woodworking machinery.

(*d*) *Foundry*, 9.5 per cent, due mainly to burns, also to falls and falling objects.

17 Then follow the various machine departments from 7.6 per cent down to 2.2 per cent, and ending with the inspection department, the offices and the drafting department with the percentage coming down to 0. Only four elevator accidents, and these slight, occurred during the six years, a very good showing with more than a dozen elevators in constant operation.

18 In the classification by seriousness of injury and length of disability of 1124 accidents occurring during the period of six years covered, 382 resulted in no disability, that is, no absence from work. In 457 cases there was less than one week's absence from work. Of the remaining 285 cases, 132 resulted in between one and two weeks' absence; 74 in two to four weeks' absence; 51 in one to three months' absence; five in three to six months' absence; and five in over six months' absence; in addition, eight were hurt so as to cause the loss of an eye, a foot or permanent injury, two dying from the effects of their injuries. Ten men left, and no record was kept of the duration of their disability. These statistics form a good basis for future investigations looking towards a still further accident reduction.

19 In 1911, with an average of 4050 employees, there were 243 accidents, or about 6 per cent of the workmen were hurt sufficiently to report; this on a basis of reporting slight accidents as well as those of a more serious character. Some of the added measures for safety had been in operation during part of the year, so that the gain from 6½ per cent, the record of the previous year, to 6 per cent for 1911, indicated a gain due to such further safeguarding. This gain was also shown in the reduced number of serious accidents included in last year's list. There were no fatal accidents; no loss of

eye or limb, and more than 70 per cent of the reported accidents resulted either in no disability or in less than one week's loss of time.

20 In some few departments, where accidents increased during the past year, special steps are being taken to ascertain the cause and to avoid a repetition. Each accident is studied to learn the lesson it teaches as to further methods of safety. It is hoped by such means to reduce the accident list to a minimum for the benefit of both workmen and employers.

THE MORE FUNDAMENTAL PRINCIPLES OF PATENT LAW

By Edwin J. Prindle

ABSTRACT OF PAPER

The purpose of this paper is to present to the engineer and manufacturer an explanation of the more fundamental principles of patent law, in plain English, without the use of legal phraseology. The paper also gives an example of a typical commercial development, undertaken for the purpose of establishing a patent monopoly, the development serving both to illustrate many phases of the procedure of conducting such a development and as a concrete example for use in explaining the principles of the patent law.

THE MORE FUNDAMENTAL PRINCIPLES OF PATENT LAW

THEIR EXPOSITION IN A POPULAR FORM IN CONNECTION WITH A TYPICAL INDUSTRIAL DEVELOPMENT, FOR THE PURPOSE OF ESTABLISHING A PATENT MONOPOLY

By Edwin J. Prindle, New York

Member of the Society

It is the purpose of this paper to give to the engineer and manufacturer a sufficient understanding of the more fundamental principles of the patent law, including the nature of a patent, the protection it may afford, how it may affect his relations with his competitors, and the principles applied by the courts in enforcing patents; so, that knowing in a general way what may be accomplished by patents, he will be "put on his inquiry" and neither let opportunities to avail himself of patents escape, nor blindly run into difficulties with the patents of others. It is not the purpose of the paper to make him his own lawyer, but rather to enable him to tell when counsel is needed and to coöperate intelligently with his counsel.

2 To make the exposition of these principles more interesting and, at the same time, to illustrate a campaign of patent engineering to establish a patent monopoly, I shall explain these principles in connection with a typical industrial development. This development is an actual experience; I have chosen it for the purpose of illustration, because it is one of the most extensive and complete efforts to develop a new commercial situation, and protect that situation by patents with which I am familiar, and therefore, I think, affords many suggestions which would be of use in attempting similar developments in other fields.

THE OBJECT OF THE DEVELOPMENT

3 For the manufacture of shoes, a very large number of lasts are made each year, amounting to several million pairs. This

Presented at the New York meeting (May 1911) of The American Society of Mechanical Engineers.

business has been conducted by over sixty different establishments, there being no patents to prevent anyone from making the ordinary last, which comprises 75 per cent of all that were used. The object of the development has been to establish a patent situation which would enable the bulk, at least, of this large business to be monopolized. The ordinary last, shown in Fig. 1, consists of a single piece of wood from toe to heel, with a detachable instep block adapted to be removed after the shoe has been built around the last, so that the main portion of the last could itself be removed. This last has certain great disadvantages, among others that it cannot bend, as the foot bends in coming out of the shoe, and consequently, the shoe is somewhat strained in being taken off the last after having been built around it, and the shoe cannot be made exactly the shape of the foot, especially the curve at the back of the heel, because if this unbendable kind of a last were made the exact shape of the foot, the shoe could not be taken off the last. Previous to the development in question, lasts had been put on the market in which the old last was made in two pieces connected by a hinge at about the

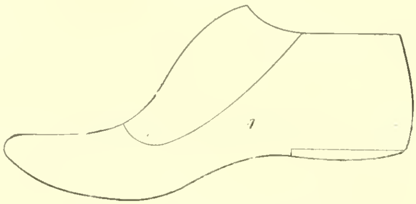


Fig. 1 Old Block Last

instep, as shown in Fig. 2, so that the last could be bent, and, in effect shortened, like the foot in taking it out of the shoe. These lasts comprise the remaining 25 per cent of those sold.

4 The shape of the toe of a last, of course, conforms to the shape of the toe of the shoe, and a manufacturer, under the old system, had as many sets of lasts as there were different styles of toes. As the heel of the last is always the shape which the manufacturer conceives to be the shape of the average human heel, it does not change with the style of the last. Therefore, it was conceived in the new development that, if lasts could be made having the advantages of the hinged last of Fig. 2, but having the toe part readily detachable from the heel, it would be possible for a shoe manufacturer to have one set of heels large enough to keep all his machines busy, and to use those heels with toes of many different styles. This would

enable him simply to attach whatever style of toe he wanted to manufacture from to his standard heels and then, in filling the next order, to use these same heels with some other style of toe. If the detachment was made between the toe and the hinge, then there would need to be only one hinge for each heel, and not a hinge for each of the separate toes. As the number of heels would be much less than the number of toes, this would effect a great saving in the cost of hinges, and consequently of lasts, to the manufacturer. When the shoe manufacturer wanted to put out a new style of shoe, he would need only to order new toe parts, and would be able to use the old heels with their hinges. The toes would need but little metal attached to them, and, if a cheap and accurate method of making the toes could be devised, it will readily be seen that the toes could be sold at a much lower cost than an entire pair of hinged lasts, comprising both toes and heels, and yet be as good to the shoe manufacturer as an entire pair of old lasts, and permit a heavy profit to be made by the manufacturer of the lasts.

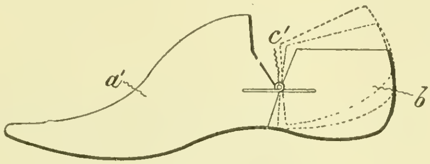


Fig. 2 Old Hinged Last

5 Therefore, the object of the development was to devise a last consisting of a toe and heel connected by a hinge, the toe being readily detachable from the hinge, and to devise machinery and methods of manufacture which would enable these parts to be cheaply and accurately manufactured, the accuracy being necessary so that any toe, when secured to any heel of the corresponding length and width of shoe, would with that heel make a complete last which would be accurate in its shape and measurements. It is necessary that the lasts be accurate in shape and measurement, because the parts of the shoe are made separately in large numbers, and, when they are assembled together upon the last, they must fit the last and each other so accurately as to make a well-made and well-fitting shoe of the desired shape and size. It is desirable to cut the parts of the shoe with as little waste as possible, because of the expense of the leather, and the greater the accuracy, the less need be the amount of waste.

NUMBER OF KINDS OF INVENTIONS WHICH CAN BE PATENTED

6 It was next considered how many kinds of patents this development is likely to form a basis for. The law provides for patenting four different classes of inventions: (*a*) arts, or, as they are usually known, methods, or processes; (*b*) machines; (*c*) manufactures; (*d*) compositions of matter.

These classes of inventions will be better understood as they are illustrated in applying them to our typical development. I may briefly define them, however, as follows:

a An art may be any process or series of steps or operations for accomplishing a physical or chemical result.

b A machine is any assemblage of mechanical elements having a law of action of its own.

c A manufacture is anything made by the hand of man that is not an art, machine or composition of matter. A knife having a stationary blade would be an article of manufacture. If, however, the blade were pivoted, it would be a machine, for it would then have a law of action of its own between its elements. The line of demarcation between manufactures and machines is not at all important, so long as it is clear that a proposed subject of a patent is one or the other of these classes of inventions, the object being to determine whether the invention is one that comes under the patent law. There are many inventions which are not patentable The department store is a very valuable invention' commercially, but is not such a one as the patent law contemplates protecting.

d A composition of matter is any mixture or combination of chemical elements, whether solid, liquid or gaseous.

A combination of elements may be patentable even though all the elements are old, taken separately, or taken in any combination less than the whole number, so long as the elements of the new combination are sufficiently related as to constitute a unity in their co-action or ultimate result.

A new use of an old device or machine or process may be patentable, if the new use is so different from the old use as not to be obvious to an ordinary skilled workman in the art.

PATENTS POSSIBLE IN THE NEW DEVELOPMENT

7 Theoretically, in our new development, there were seven different classes of patents which could be obtained.

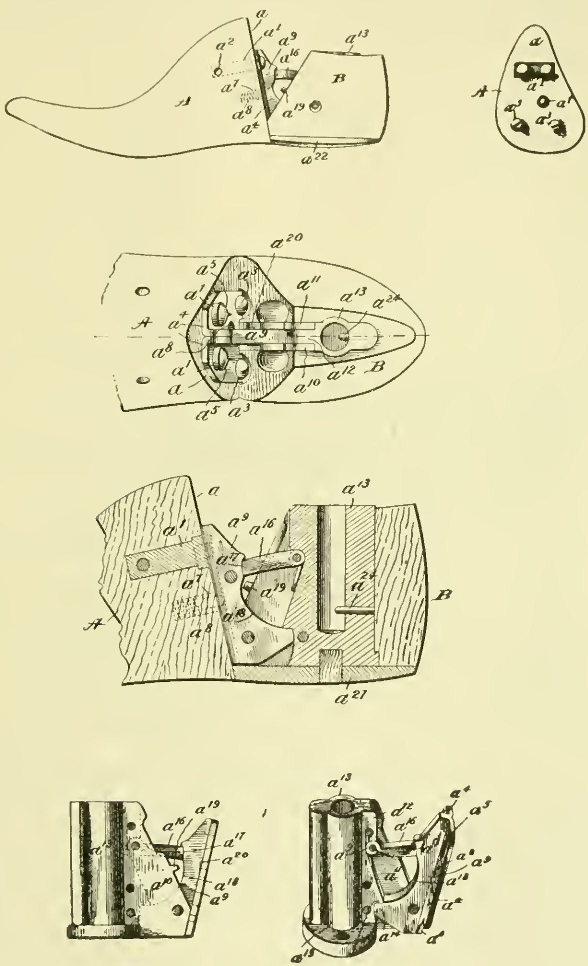


FIG. 3 DOE'S NEW LAST

a A patent on the last having a toe readily detachable from the hinge.

b A patent or patents on a method or process, or procedure, or series or succession of steps or operations for so making

the lasts that the toe and heel parts would be interchangeable, and that when any two of them were fitted together they would make a last accurately conforming in shape and dimensions to the model required.

c A patent or patents on machinery for practising such a method or process.

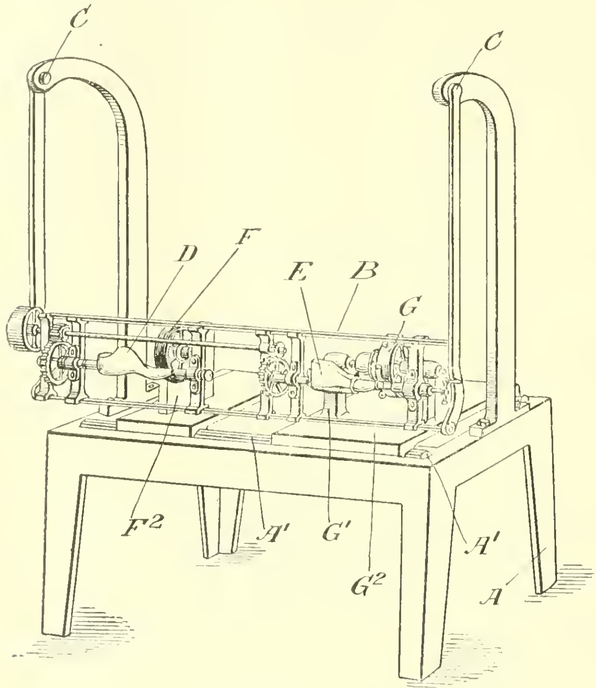


FIG. 4 OLD LAST LATHE

d A patent on a blank from which the interchangeable toes and heels were to be made by such method.

e A patent on a new composition of matter from which the lasts could be made.

f A patent on an advantageous method or procedure of making shoes which the new last made possible, and which will be later explained.

g A patent on a combination of the removable toe with an expansible leg in a shoe dressing and ironing machine.

8 The first task to which the inventor of the new development (John Doe, as we shall call him for the purpose of this paper) set

himself was, therefore, to invent a last consisting of a toe and heel connected by a hinge, the connection between the toe and the hinge being of such a nature as to be readily detachable when desired, and yet the whole structure be rigid and strong when the last is in condition for use. This last is shown in Fig. 3.

9 The last, briefly, consists of a toe A and heel B connected by a hinge. The toe has two studs a^1 and two screws a^3, projecting from its rear face, for the purpose of detachable connection with the front plate a^4 of the hinge, the said plate having upper key-hole slots a^5 which engage the studs a^1 and lower key-hole notches a^6 which engage the screws a^3. A small spring bolt a^7 is also mounted in the rear face of the toe to engage a hole a^8 in the plate and lock the plate on the last when it is home on the studs. A plate a^9 extends rearwardly from the plate a^4 and is pivoted between plates a^{10} and a^{11} fastened to a projection a^{12} of a drop forging a^{13} in the heel B. A shoulder a^{14} on the rearwardly projecting plate a^9 engages a shoulder a^{15} on the drop forging, when the last is in extended position, to prevent the hinge from opening too far. A locking piece a^{16} is pivoted between plates a^{10} and a^{11}, and bears against a shoulder on the plate a^9 to keep the hinge extended. A spring normally tends to throw the locking piece into locking position. When the last is to be collapsed, the locking piece is depressed and held down until the collapsing movement causes it to be caught by a cam surface a^{18} on the plate a^{19}, after which the unlocking device can be withdrawn, and the cam surface will complete the depressing of the locking piece by the collapsing movement. A projection a^{13} on the plate a^{11} is caused by the collapsing movement, to push back the spring bolt a^7, so that the last is not only collapsed, but the hinge is unlocked from the toe, and the toe can be removed. The forging a^{13} is provided with a flange at its lower end to which a metal heel plate a^{27} is fastened, so that the heavy operations in the early part of the making of the shoe can be borne by the metal parts of the heel, the wood being insufficient to stand the strains.

10 Having invented the last, it was necessary to be able to make it, as before stated, so that the toes and heels of the same length and width should be absolute duplicates, and interchangeable. Commercially, it was necessary to be able to make these toes so that they would accurately and interchangeably fit heels in a perhaps distant shoe factory, made, perhaps, several years before.

11 The machinery and method of manufacture of hinged lasts which were in use at the time of the new development were incapable of making interchangeable last parts. Such old procedure was to make a model last which met the approval of the shoe manufacturer and then to duplicate that last in a lathe, variously known as the Blanchard, or gun-stock, or last-turning lathe. Such a lathe is illustrated in Fig. 4. The lathe consists essentially of a stationary frame *A* having a "swing frame" *B* pivoted thereto at *C*. The swing frame has headstock spindles and dead centers which are adapted to support a model last *D* and the block *E*, from which the new last is to be formed, and to rotate them on axes in

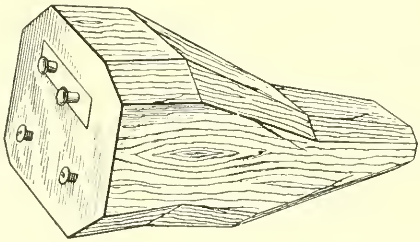


Fig. 5 Doe's Blank for Making Last Toes

line with each other. On the frame *A* are journaled a model wheel or tracer *E* and a cutter head *G* of exactly the same diameter as the model wheel and describing a similar surface of revolution. The model wheel pivot is mounted on a slide (not shown) adapted to move forward and back across the machine on an upright F^2 that is carried by a slide mounted on a guide A^1 extending lengthwise of the main frame. The cutter head is mounted on a journal having bearing in uprights G^1 carried by a slide G^2 which also travels on the guide A^1.

12 In the operation of the lathe, a spring or the weight of the swing frame normally draws the swing frame towards the main frame until the model rests against the model wheel or tracer. As the model revolves, it swings the swing frame back and forth, so that the cutter head cuts out of the block, or blank, a new last of the same shape as the old one. The carriages of the model wheel and cutter head are caused slowly to travel lengthwise of the main frame so that all parts of the model surface are presented to the model wheel and the corresponding parts of the new last are shaped.

13 The action of the lathe is as though the tracer or model wheel moves, while the swing frame remains still the model revolving on its axis, however, and the cutter controlled by and moving in unison with the tracer, duplicates the shape of the model in the block. The model is a cam, controlling the cutter through the tracer, or model wheel.

14 By means of certain grading mechanism (not shown), the model wheel carriage F^1 may be moved in and out, proportionately, as the swing frame moves, so that a wider or narrower last will be formed than the model. By means of certain other mechanism (not shown), the proportionate travel of the main carriages F^3 and G^2 may be varied so that a longer or a shorter last will be formed. It will be seen that the new last is formed in a single piece from toe to heel, and in practice a "nub," or unfinished portion, is left at the toe and heel where the chuck and dead-center support the wood.

15 The old procedure of making hinged lasts was to make duplicates of the model of a single piece of wood from toe to heel, as though an old solid last were going to be made, and then to saw up this one-piece last into a toe and a heel and fasten these parts to a hinge. Of course, the toe and heel which were sawed apart would always fit together, because they were originally parts of the same last. As, however, a last has no straight lines and no corners to measure from or gage by, and is wholly composed of irregular curved surfaces and lines, it is impracticable, as a commercial proposition, to saw up whole lasts so that the toes and heel will be interchangeable.

16 Our inventor, Doe, solved the problem in the following manner. He conceived the idea of providing the model headstock of the old spindle last-turning lathe with a face plate against which the rear face of the model toe part could be held, and providing the headstock spindle for holding the rough block out of which the new part was to be made, with a face plate parallel to the model face plate. He then made a blank, as shown in Fig. 5, which consisted of a block of wood having a dressed end, which is to form a rear face of the new toe part, and having studs and screws fastened in it, precisely like the model toe. In order to hold the model toe and the blank against their face plates, Doe provided chucks which are shown in Fig. 6. These chucks consist of a spindle h having a face plate h^{20} and having cylindrical plugs (see lower right-hand corner Fig. 6) journaled in the head of the chuck. The plugs have undercut recesses h^8 which are adapted to receive the heads of the studs and screws on the toes. The plugs have collars on their shanks which

engage notches in the corners of a plate h^{12}, the latter having a shank h^{13} pivoted to a screw-rod h^{14} which can be moved back and forth by a hand wheel h^{15}. In the operation of the chucks, the plugs being in their forward position and their undercut slots exposed, the studs and screws on the toe or blank are engaged with the undercut slots,

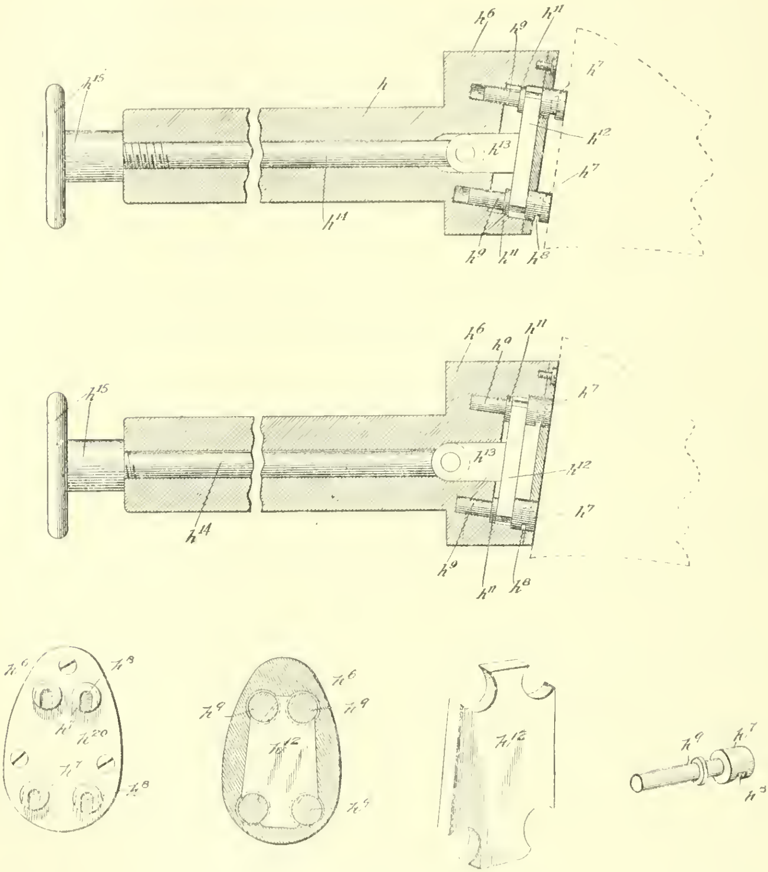


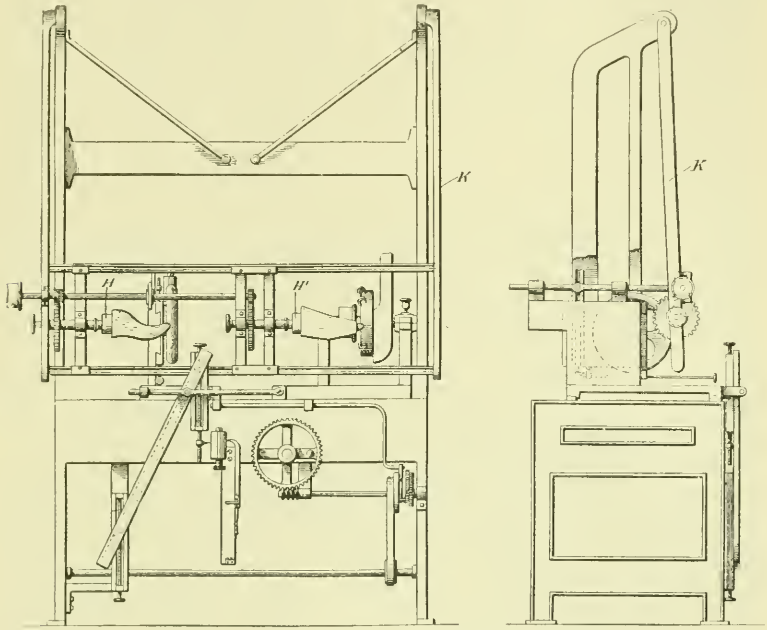
Fig. 6 Doe's Chuck for Toes

and then the plate h^{12}, and plugs, being drawn rearward, draw the studs rearward, thus drawing the toe or blank against the face plate.

17 Figs. 7 and 8 show a last-turning lathe which is the same in principle as that shown in Fig. 4, but having Doe's chucks *H* and

H^1 mounted in the headstocks of the swing frame K. The swing frame is like that of the lathe of Fig. 4.

18 In Doe's method, the rear faces of the model toe and the toe being formed are always parallel, and, as the foot-shaped contour is formed on the blank parallel to the foot-shaped contour on the model, the foot-shaped contours of the model toe and the new toe bear the same relation to their rear surfaces, and these toes are,



Figs. 7 and 8 Lathe Having Doe's Chuck Applied and Practising Doe's Method of Turning Last Toes

therefore interchangeable. Incidentally, Doe also finishes the entire tip of the new toe by the machine, and saves the cost of doing it by hand-labor, as required by the old process, a cost nearly as great as that of turning the entire remainder of the last. Figs. 9 and 9*a* are photographs of Doe's lathe practising his method of turning last parts.

19 Doe's method, then, consisted in forming a finished or standard surface on the rear end of his blank, corresponding to the rear surface of the model toe, and then, so mounting the toe and blank in the lathe that these rear surfaces shall always be parallel to each other,

and forming a foot-shaped contour on the blank by a cutter guided by the foot-shaped contour on the model toe. This method or procedure was patentable under the statutory head of "arts," and we shall see later exactly how it was protected.

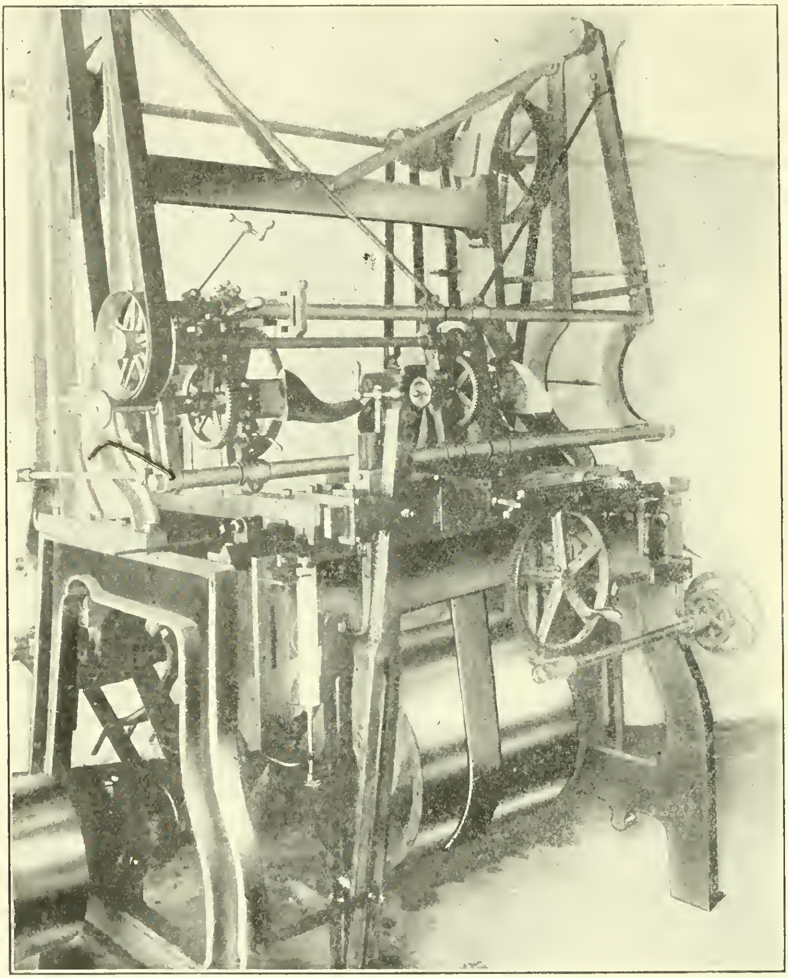


Fig. 9 Doe's Actual Lathe

20 It was necessary for Doe to make certain improvements in the grading mechanism of the lathe, whereby the new toe could be made longer or shorter, or wider or narrower, than the model

toe, because with the grading mechanism of the old lathe, he could not foretell with exactness the length of the new toe which would be produced, as he must be able to do if it were going to bear only its proportionate part of the length of the last, to make a last of

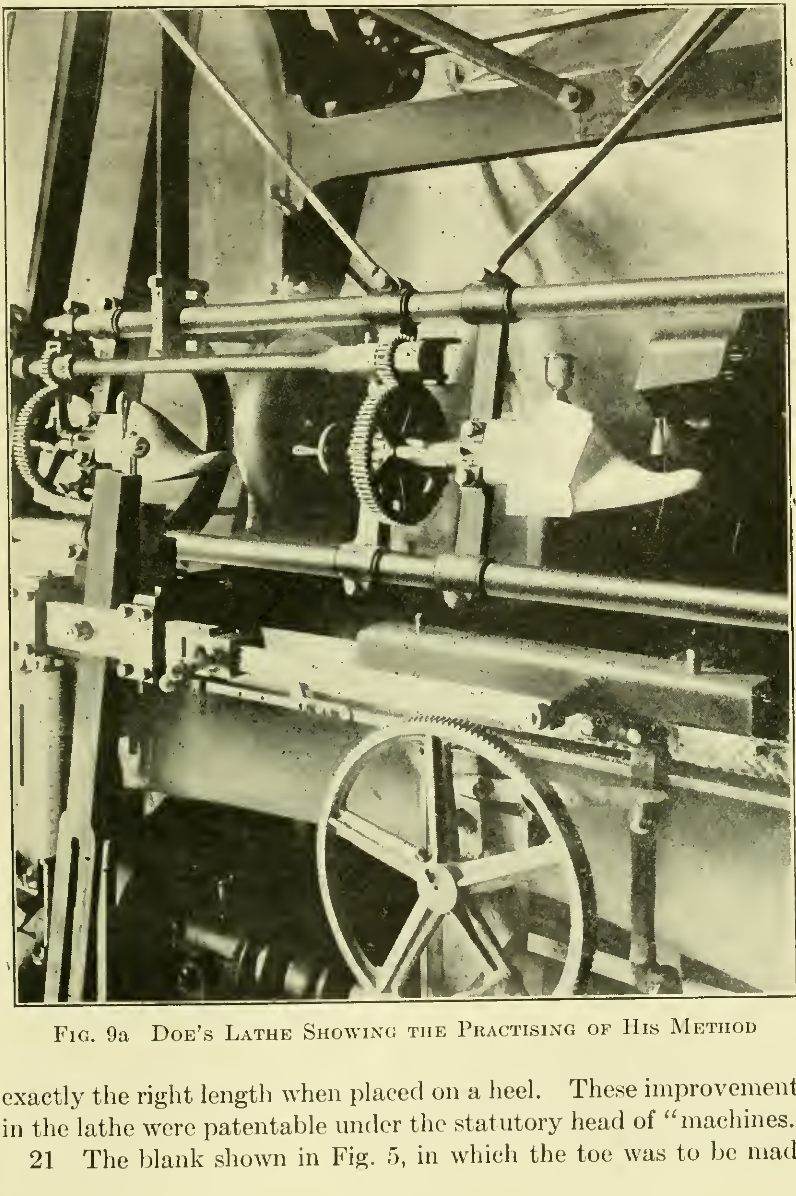


Fig. 9a Doe's Lathe Showing the Practising of His Method

exactly the right length when placed on a heel. These improvements in the lathe were patentable under the statutory head of "machines."

21 The blank shown in Fig. 5, in which the toe was to be made

was patented under the statutory head of articles of manufacture. If Doe had been able to discover a composition of matter which is as strong as the rock maple, from which lasts are universally made, but which does not have the disadvantage of shrinking and swelling with the variations of humidity, he could have patented this composition under the statutory head of compositions of matter.

22 In the manufacture of shoes, the parts of a shoe are built around the last, and the operations which cause severe strain on the last, such as the operations of drawing the upper around the last, or "lasting," rolling the sole to shape it to the last or "sole leveling," and driving the heel on to the last (the heel being made separately and fastened on all at one operation) or "heeling," all occur during

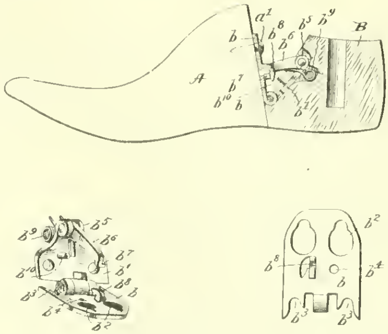


FIG. 10 DOE'S LIGHT HEEL FOR HIS LAST

the first few hours of making the shoe, while subsequent operations and the drying of the shoe on the last (which is done with every good shoe) take much longer. As the shoe is built around the last, it is desirable that it should dry on the original toe upon which it is built, since it is impossible to take that toe out and put another toe in and have the new toe fit perfectly into the shoe. Doe, therefore, wanted to leave his toe in the shoe throughout its manufacture, but conceived that, since his heel was heavy and somewhat expensive, to make it strong, if he could take his heavy heel out of the last when the heavy operations were over and put in a lighter, cheaper heel, this would enable the expensive, heavy heel to go back and begin at once the manufacture of a new shoe, thus reducing the number of heavy heels which a manufacturer would need and also saving the workmen the effort of handling the shoes with the heavy heels in them

23 Doe, therefore, invented a light heel shown in Fig. 10. The hinge consisted of a front plate b adapted to engage the studs and screws on the toe, a rear plate b^1 hinged to the front plate and adapted to be screwed to the wooden heel B. A locking piece b^6 is pivoted to the rear hinge plate and is adapted to engage a hook b^8 on the front hinge plate when the last is extended and to be flattened down out of the way when the last is collapsed. The collapsing of the last shortens it enough to allow room in the shoe for engagement or disengagement of either hinge with the studs and screws on the toe.

24 Doe was, therefore, able to collapse the heavy heel and disengage it from the toe and withdraw it from the shoe, and to insert the light heel with its hinge collapsed, engage the hinge with the studs and screws of the toe, and swing the light heel into normal, extended position without disturbing the toe in the shoe.

25 Doe patented both the combination of the single toe with the light and heavy heels, and the method of making shoes which consists in starting the manufacture with a toe and a heavy heel, and then, after the heavy operations on the shoe are over, removing the heavy heel and substituting the light heel, and continuing the manufacture of the shoe.

26 In the manufacture of shoes, as practised before Doe's invention, finer grades of shoes were placed upon a form consisting of a foot and a leg on which they were dressed and ironed, as the last step before going into the boxes for shipment. As Doe had made his toe removable from the hinge, he invented a leg to which it could be attached, and that, without disturbing the position of the toe in the shoe, so that he not only saved the expense of the special toes for this ironing operation, but the labor of replacing the last by the special toe, and he thus made it possible to conduct the manufacture of the shoe, from beginning to end, upon a single toe around which the shoe was built and which was never disturbed, the manufacture starting with a heavy heel which was later replaced by the lighter heel, and that later replaced by the expansible leg of the machine upon which the shoe was ironed. The combination of the heel and leg with a toe adapted to be attached to either of them, was patentable.

27 As in all developments, the last and machinery went through more or less evolution, usually more, and a system and special machines were invented to prepare both the toe and heel blanks to fit the hinges so that they might be given their foot-shaped contour in accordance with the method which Doe had invented. It is unneces-

sary to describe any of these evolutions and machines, as what has been described is sufficient for the purpose of an illustration, both of the method of producing such a commercial development and of the types of inventions which can be protected.

THE NATURE OF A PATENT

28 Having now sketched the development, I wish to explain how it was protected by patents, and for the purpose of doing so, shall endeavor first to explain the nature of a patent.

29 The law provides for the granting of patents only to actual inventors and requires, as the price of the patent, that the inventor shall describe his invention so fully that anyone skilled in the art

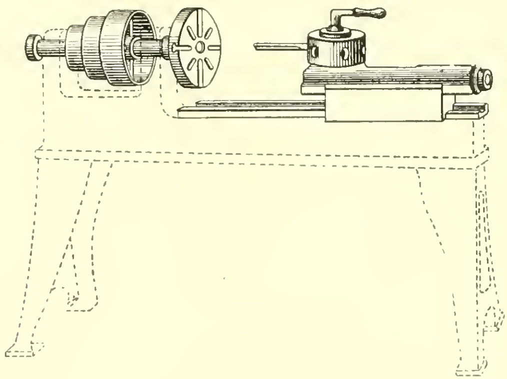


Fig. 11 Turret Lathe

can make and use the invention after the patent has expired, the law giving the inventor, in compensation, an absolute right for a period of 17 years to forbid all others from making, using or selling the invention. As every invention is an evolution from ideas which preceded the inventor's conception, occasionally being the last step of a series of improvements extending through centuries, some, and often much, of the structure or procedure which the inventor discloses is not his own invention, but is the foundation upon which he has built or from which he evolved his invention.

30 In order that the public may know what it is free to do, and in order that the courts may know when an invention has been used by others, the law requires the inventor to point out the part,

improvement or combination, which the inventor regards as his invention or discovery. The necessity for this has developed the practice of requiring the inventor to make one or more series of short, terse statements or descriptions of what he regards as his invention, at the close of his detailed description, these statements being technically known as claims.

THE NATURE OF A CLAIM

31 A claim is the measure of the monopoly granted by the patent, and it is vital, therefore, that it be skilfully drawn; for most inventions are an "idea of means" embodied in a particular form, and many clever mechanics could get the same result by

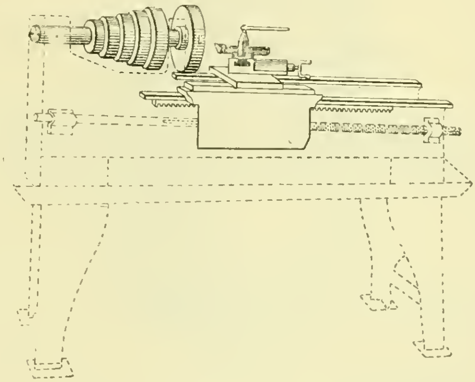


Fig. 12 Lathe without Turret

changing the form of embodiment without changing the principle of the invention, or the idea of means. It is therefore very desirable that the monopoly granted by the claims shall be broad or comprehensive enough to include all possible changes of embodiment which do not involve a change in the idea of means.

32 For the purpose of illustrating the nature of a claim, I shall deviate temporarily from our example of a commercial development, using certain machine tools for the purpose of illustration, as they are a more convenient form of illustration for this particular point.

33 We will suppose our inventor, John Doe, to have invented the first turret lathe. Doe might have claimed his invention as follows:

I claim a machine tool consisting of the combination of a bed having ways, a headstock on said bed, a spindle journaled in said headstock, a chuck on

said spindle, a slide mounted on said ways, a turret revolubly mounted on said slide, a series of tools mounted in said turret, a rack on said slide, a pinion journaled on said bed and engaging said rack, and a hand wheel for turning said pinion, whereby a piece of work may be secured in and revolved by said chuck, whereby said turret and tools may be advanced against and retracted from the work, and whereby said turret may be turned to bring its various tools into cutting position.

34 Suppose, now, that Doe's turret lathe was the first machine ever invented in which the work was revolved, and a tool mechanically held on a slide was moved against the work. Suppose that

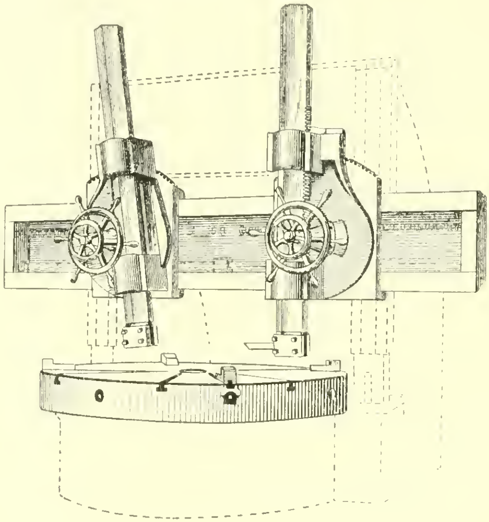


Fig. 13 Boring Mill

after Doe's invention, the lathe without a turret, the boring mill, the pipe-threading and cutting machine and the locomotive tire-boring machine were invented. It is apparent that, at least in a general way, these tools work on the same principle as Doe's turret lathe. In Figs. 11–15 I have illustrated the five types of machines to which I have referred, and have shown in full lines in each machine the revolving work holder (such as the headspindle of the lathes, the table of the boring machine, etc.), the tool carriage, and the guides on which the tool carriage is mounted, these being the essential features of Doe's invention and being features which are found in every one of the five types of machines. The features, other than

the essential features, which differ in the various machines are illustrated in phantom lines. It will be seen that although all of the four machines following Doe's invention use the basic idea embodied in his machine, none of these machines answers to the description of his invention which he made in his claim. For instance, none of them has the turret, and most of them lack other elements of his claim. The courts will not permit an inventor to enjoin the use of a machine which omits an element of his claim. If the inventor describes his invention in a claim consisting of six elements, and some one else finds that he can accomplish the same results by

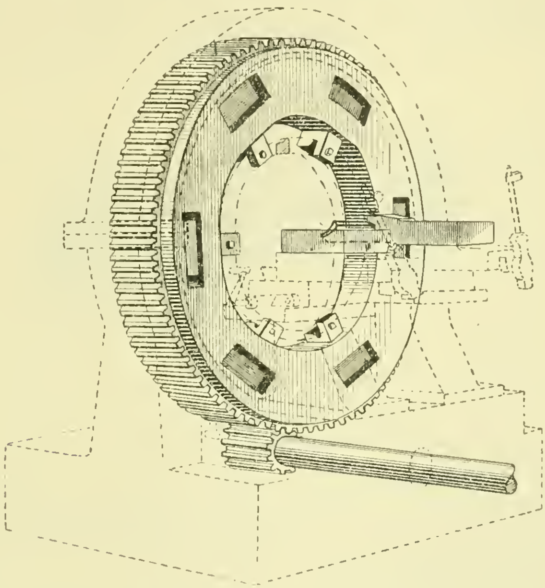


FIG. 14 MILL FOR BORING LOCOMOTIVE TIRES

the use of five elements, the courts will not ordinarily hold the latter machine to be an infringement of the claim. The inventor is bound by his statement of his invention to the extent at least that one who uses less elements than the claim states does not infringe.

35 If, however, Doe had made his claim read:

I claim a machine consisting of the combination of a frame, means mounted on said frame for revolving a piece of work, guides on said frame and extending toward the position of the work, a part mounted on said guides, and a tool on said part, whereby said tool may be held against and guided along the said work for cutting the same.

he would have described his invention as truly as his more prolix claim including the turret, and yet he would have stated his invention so broadly that his claim would have described each one of the four subsequent machines quite as correctly as his own machine, for the claim would only be descriptive of the full-line parts of the five figures.

36 It will thus be seen that every invention is, so to speak, a soul incarnated in a body, and that the form of embodiment can usually be changed, and frequently infinitely varied without altering the nature of the soul. A further illustration would be to suppose, without irreverence, that some one invented the first animal having a vertebrated skeleton. All subsequent vertebrates would be embodiments of his invention, no matter how much more highly

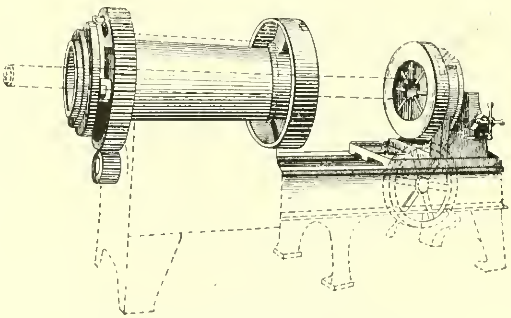


FIG. 15 PIPE CUTTING MACHINE

developed they might be or how much adapted for different conditions of life, such as in water, or in the air, while the first vertebrate was adapted only for life on land.

37 It will thus be seen how vital it is that the one drafting the claim should be able to determine what is the soul of the invention, and to distinguish it from unessential details of the particular form of embodiment, and to express in the claim only the characteristics of that soul. It is also apparent that the less a claim says, the greater the monopoly granted by it.

PATENTING DOE'S METHOD OF TURNING LASTS

38 In analyzing the Doe method of turning lasts, for the purpose of drafting the claim, it was seen that there were essentially two steps: one, the forming of the rear, abutting, geometrical or hinge-

attaching surface on the toe part; and the other, the forming of the foot-shaped contour. Doe first forms the geometrical surface and afterwards forms the foot-shaped contour. The old method of forming the hinge last was first to form the foot-shaped contour and afterwards form the geometrical surface. It would appear, therefore, at first blush, that all Doe needed to protect him was a claim for the method of forming last parts which consists in first forming a geometrical or hinge-attaching surface on the blank, and then so supporting the model and the blank in the lathe that their corresponding geometrical surfaces should be parallel, and, finally, forming the foot-shaped contour on the blank by a cutter guided from the model. This would differentiate his invention from the prior art and would, apparently, protect its essence.

39 Doe was apprehensive, however, that some other way of making interchangeable last parts was possible than the one he had invented, and which would not be described by the proposed claim. Doe, therefore, analyzed the problem as follows: Any method of making a toe must consist of two steps, the forming of the geometrical surface, which we will call step *A*, and the forming of the foot-shaped contour, which we shall call step *B*. There are only three possible combinations or arrangements of these steps. *A* followed by *B*, *B* followed by *A*, and both steps together. This showed that all possible processes of making these last parts by cutting must fall within three generic classes, however they might differ as to details. Doe's method which he had already invented is an embodiment of the first type. The old prior art which could not produce the last parts interchangeable is an embodiment of the second type. If, therefore, Doe could invent an embodiment of the third type, he could absolutely monopolize all commercial methods of making the interchangeable last parts. He, therefore, set himself to invent an embodiment of the third type.

40 I will not cumber the paper by describing Doe's embodiment of the third type in detail with drawings, but will give simply a brief verbal description of it.

41 Doe arranged the face plate which supported the geometrical surface on the rear of the model toe so that that surface would be perpendicular to the axis of the spindle on which it revolves in the lathe. He then mounted the blank in any convenient way in the lathe and turned the foot-shaped contour in the usual way, by a cutter guided from the contour of the model, and then acted on the rear surface of the blank simply by running the cutter head straight

inwards toward the axis of revolution. This formed the rear surface of the new toe perpendicular to the axis of revolution and parallel to the similar surface on the model toe. While the new toe was supported on centres, Doe drilled holes where the screws were to go, and by means of these holes and the partially formed rear surface, he could place the toe, first in a machine for removing the nub where the centre supported the toe on its rear end and then in a machine for forming holes to receive the plug carrying the studs. The same principle was applicable to the forming of a heel.

42 This second, or alternative method, which Doe had thus invented might be commercially undesirable, but so long as it was physically possible to form interchangeable last parts by means of it, it was sufficiently an invention to make the basis of a valid patent and give Doe the second monopoly which he sought, namely, one to protect the third type, in which both steps were performed together.

43 Doe now set to work to see if he could not find a principle common to both of his types of method, and, if found, to draw for it. The result was the following claim:

The method of forming last parts, which consists in providing a model having a toe and heel part, each having a regular surface, said surfaces having a definite geometrical relation to each other in the complete last, preparing a last part by providing a block with a regular surface, and turning a foot-shaped surface thereon by a cutter guided from the foot-shaped surface of the model, the cutter which last performs its operation on the block moving in a path having the same relation to the axis of revolution of the block as the corresponding surface of the model bore to its axis of revolution.

44 This claim does not state whether the geometrical or regular surface is formed before the foot-shaped contour, or after. It correctly describes any process in which one of the two surfaces on the new toe is formed and then the other of those surfaces is formed, while the first surface, be it geometrical or foot-shaped contour, is held parallel to the corresponding surface on the model. This, then, is an essence or soul common to both the Doe methods, and the single claim protects them both. The effect of Doe's final claim was to reduce his two methods from independent genuses to species of a single genus.

INFRINGEMENT

45 We will now consider how a court applies a patent as a practical matter in a suit for the infringement of it, by the making,

using or selling of an article which the patentee complains of as embodying the patented invention. If the competing device was a copy of the patented device, there would be no difficulty in reaching a decision. But those who seek to evade a patent seldom make Chinese copies of the patented device.

46 Suppose, then, for the purpose of illustration, that Doe had not foreseen the possibility of the third type of method of forming his toes and had not drafted his claim as broadly as the one quoted, but had drawn the following claim:

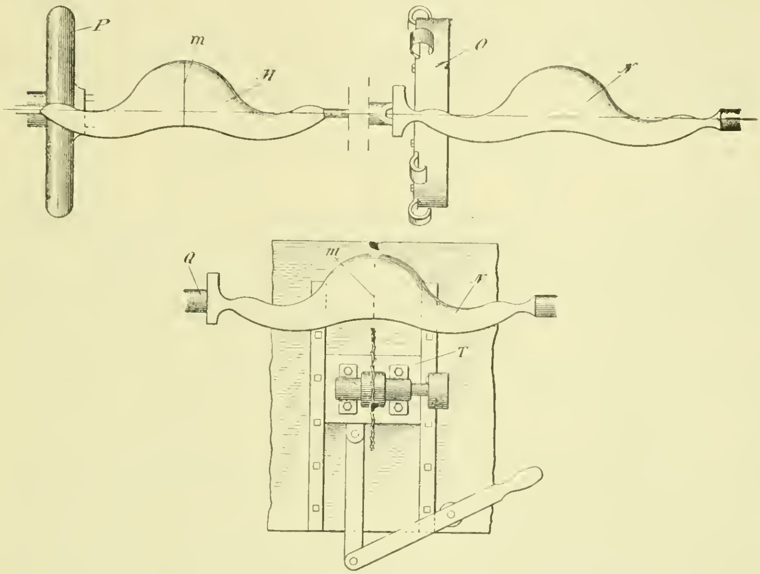


Fig. 16 The Competitor's Attempt to Evade Doe's Claim for his Methods of Turning Lasts

The method of forming last parts which consists in forming a geometrical surface on the blank corresponding to a geometrical surface on the model, so supporting the blank and the model in the lathe that such surfaces shall be parallel, and then forming the foot-shaped contour on the blank by a cutter guided from the model.

47 Suppose, now, a competitor then sought to evade the patent in the manner indicated in Fig. 16, that is, by forming a model M, consisting of two toes put butt to butt and turning a double blank N by a cutter O which is controlled from the model wheel P in the ordinary manner. Suppose the competitor mounted the blank upon

two centers Q and R, on a sawing machine having a circular saw S mounted on a carriage T traveling between guides, the saw being so placed with reference to the centres that it would saw the blank on a plane n exactly corresponding to the plane m of the model, thus making two toes in which the geometrical surfaces bear exactly the same relations to the foot-shaped contours as in the model.

48 This method of the competitor would avoid the narrower claim of Doe just quoted above, but would clearly infringe the broad claim first recited. Under our present supposition (that Doe had not discovered the possibility of the third type of method and had not drawn a claim broad enough to cover both types) he would be in the unfortunate position of having somebody utilize his discovery as a basis for doing the same thing in a different way and escaping his claim, and yet really using his invention after all.

THE DOCTRINE OF EQUIVALENTS

49 This is a situation which has frequently arisen in the courts, and the inequity of it has appealed to their sympathy. Claims are frequently unskillfully drawn, and the courts, in order to afford relief in meritorious cases, adopted what is known as the doctrine of equivalents, under which it is held that a patentee is not only entitled to what he claims, but to every equivalent of it. An equivalent is defined to be that which performs the same function in substantially the same way. This phrase, "substantially the same way," is indefinite and permits the court to do what it conceives to be equity in any particular case. If the invention is one of decided novelty and of great service to the public, the courts will hold almost anything which performs the same function as the patented element or combination to be an equivalent. If, however, the margin of novelty is small, the courts will require the elements or combinations to be almost identical with that specified by the claim to be an equivalent.

50 In the present instance, it would be argued that the essence, or soul, of Doe's invention consisted in forming a regular surface on the blank for the new toe and turning a foot-shaped surface thereon by a cutter guided from the foot-shaped surface of the model, the sole essential condition being that, whichever cutter last performs its operation on the block shall move in a path having the same relation to the axis of revolution of the block as the corresponding surface on the model bore to its axis of revolution. It will be observed

that the competitor carefully preserved the location of the axis of revolution in the block by preserving the centres and using the centres to position the block, so that the saw in forming the surface *n* moved in a path having the same relation to the axis of revolution of the block as the surface *m* of the model bore to its axis of revolution. This is the very condition, the lack of which made interchangeable last parts an impossibility by the prior art. For, in the old method the ends of the toe and heel were finished before the last was sawed to divide it into the toe and heel, and this finishing of the toe and heel destroyed the centres, so that the sawing was done by eye or guess-work.

51 It would be entirely in accordance with many previous decisions for the court to hold that Doe, having made an invention of decided novelty and commercial value, was entitled to a broad range of equivalents, and that although his claim was limited to the particular procedure by which he had illustrated his invention, namely, to forming first the geometrical surface and afterwards the foot-shaped contour, still the competitor's way accomplished substantially the same result in substantially the same way, because it utilized the essential condition above pointed out, and therefore, what the competitor did came within the monopoly granted by the patent and should be enjoined.

DEFENCES TO AN INFRINGEMENT SUIT

52 It would be open to the competitor to show that the patent to Doe was invalid for any one of a number of reasons. For instance, if the competitor could show that the invention was known or used by others in this country before the patentee invented it, the patent would be held to be invalid. If, however, as actually happened in the present instance, Doe's counsel, on cross-examining the competitor's witnesses, should show that the use of the invention before Doe's invention of it, was in secret, and only the necessary employees of the competitor were allowed to see it, and precautions were taken to preserve the knowledge of the method from the public, then the prior use would not be held to invalidate the later patent granted to Doe. The reason is that the object of the patent law is to induce inventors to give the public a knowledge of their inventions, so that the public may use the inventions after the patents are dead, and if a person keeps an invention secret, the public does not then get any benefit of it, and might never get any benefit of it,

since the knowledge may die with those possessing it. Therefore, the courts will not invalidate a patent to a subsequent original inventor because of an earlier secret use. If the competitor could show that the invention was in public use, or described in a printed publication for more than two years before Doe filed his application, no matter if it all occurred after Doe made the invention, and was Doe's own public use of the invention, or printed description of it, his patent would be held to be invalid. There are other defences which the competitor might raise, but these are the principal ones.

53 A patent, being a public grant, is presumed to be valid, and only the strictest proof of one of the defences will enable it to prevail against the patent.

CONTESTS BETWEEN RIVAL CLAIMANTS TO AN INVENTION

54 Without previously stating the principles by which contests between rival claimants to an invention are decided, I will illustrate them by a contest which occurred in the present development.

55 Doe conceived of his method of forming interchangeable toe parts, and filed his application for patent in the month, let us say, of June. He filed his application for patent without previously trying the method, or actually practising it, by the use of machinery. An interference, or contest, was declared between Doe's application for patent and an application of another party, whom we will call Richard Roe, which was filed in May. Roe, being the first to file his application, was presumed to be the first inventor, and the burden of proving he was not the first rested on all later comers, including Doe. While testimony was being taken in this interference, it was interrupted and re-declared, adding a third party, whom we will call John Mark, and whose application for patent was filed in November. It developed that Mark had filed an application for patent the previous year, and by failing to prosecute it with that promptness required by the Patent Office rules, it had become what the Patent Office terms abandoned or dead. Mark claimed that Roe had derived a knowledge of the invention from him (Mark), and that, therefore, Roe had never made the invention, in the sense that he had never generated it in his own mind, and so had wrongfully applied for a patent, as the law provides only for the granting of patents to actual inventors.

56 In determining these contests between rival claimants for a patent, the law considers an invention to consist of two steps: first, the mental conception, and second, the reduction to practice of that invention, or the embodiment of it in a form sufficiently perfect, so that the invention can be used by the public without any further exercise of the inventive faculty. The law considers the reduction to practice accomplished when either of two things has been performed by the inventor, or by those acting for him at his request. Either he must build a machine or an article of manufacture, if the invention be a machine or article of manufacture, or the apparatus or mechanism for practicing a method, if the invention be a method, and he must, ordinarily, demonstrate the perfectness of the machine, article or method actually by operating it. Or he may file an application for patent for the invention, and, if the examiners of the Patent Office decide that that application discloses an operative form of the invention, the filing of the application is considered equivalent to the actual reduction to practice by mechanism, and is technically known as a constructive reduction to practice.

57 In an interference contest, the original inventor who is the first to conceive the invention, and who follows his conception by substantially uninterrupted diligence in reducing it to practice, ending in a successful reduction to practice, either actual or constructive, is entitled to the patent. The law does not require that the first conceiver of an invention shall also be the first to reduce it to practice, so long as he connects his conception to reduce to practice by reasonable diligence. But, as before stated, the burden of proof as between any two contestants is on the later comer into the Patent Office.

58 A simple graphical diagram will be of assistance in settling the contest we are considering. In Fig. 17 is shown a diagram of the production of an invention. We will represent the conception by a vertical line, the reduction to practice by another vertical line, and the diligence in maturing the conception into a successful reduction to practice, by a horizontal line. A complete inventive act, therefore, will consist of two vertical lines connected by a horizontal line. An interruption, or delay in carrying out the reduction to practice will be represented by dotting that portion of the diligence line.

59 We are now in position to draw the diagram in Fig. 18, representing our contest for the patent. As Mark was the earliest to conceive the invention, his conception should occur farthest to

the left, being the date when he filed his first application for patent. The period between this date, and the filing of his second application for patent, being a period of inactivity should be represented by a dotted line, showing there was no diligence in reducing the invention to practice. When Mark began the preparation of his second application for patent, his diligence really began, and from then on to the filing of his application for patent, his diligence line is a solid line. As Roe derived his conception of the invention from Mark, we can give him no conception line, but simply a diligence line, ending in a constructive reduction to practice in the filing of application for patent. Doe, last of all, conceived the invention, and connected his conception, by reasonable diligence, with his constructive reduction to practice in filing the application for patent.

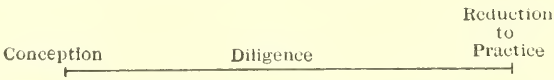


Fig 17 Diagram of the Production of an Invention

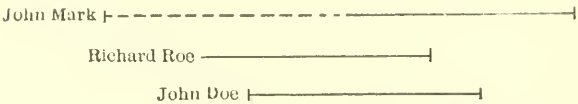


Fig. 18 Diagram of the Doe vs. Roe vs. Mark Contest for the Patent

60 As Roe never performed the complete inventive act, since he never conceived of the invention himself, he was not entitled to a patent, even though he did file an application for a patent on the invention earlier than Doe's application, and earlier than Mark's second application, therefore it is either Mark or Doe who will be entitled to the patent. As Mark's first application for patent became abandoned, the law only regards it as evidence of conception of the invention, and neither as evidence of diligence, or reduction to practice. As Mark was, therefore, as the courts have termed it, "sleeping on his rights" at the time Doe entered the field, Mark is restricted to the date when he filed his second application for patent, which, in effect, makes his conception of the invention later than Doe's conception of the invention, the law regarding it as though Mark had never conceived the invention until he filed his second application for patent. This makes Doe the first of the three to conceive

the invention, and as Doe diligently followed his conception by a constructive reduction to practice, he was legally the first inventor and secured the patent.

61 While it is impossible, within the limits of such a paper as the present one, to give a complete statement of all the fundamental principles of the patent law, the purpose of the paper has been accomplished if it has given an intelligible understanding of a sufficient number of those principles to put the engineer and manufacturer on his guard, so that he may know what can be accomplished, and when, and how to utilize his counsel in such matters.

TAPS AND SCREWS

At the meeting of the Society held in New York, March 12, 1912, a paper by F. O. Wells of the Wells Brothers Company, Greenfield, Mass., was presented by H. E. Harris, testing engineer for the company, on Taps and Screws.

The average user of machine screws and bolts hears very little about the finely drawn theories in regard to angles and other details and their practical application to tap and die making. The ability to buy or make screws and bolts which can be depended upon to fit the tapped holes in the product under manufacture is, however, a matter which demands attention. Differences in the dimensions of the screws and the tapped holes must be made in order to allow for unavoidable imperfections in manufacture and wear on the taps and sufficient freedom of fit, but this should be confined to such small limits that the smallest permissible diameter for the taps will be slightly larger than the largest permissible diameter for the screws. If these limits are too large, a screw which happens to be used in a hole tapped by a maximum sized tap may be too loose. The limits must be closely guarded; but at the same time they must not be so small as to prevent an interchangeable assembling, and must also allow for a reasonable amount of wear on the tap.

The two factors most vital in this connection are the size and the lead. It is very important to understand how the size is to be measured. The fit of any screw should be on the sides of the angle of the thread, as the outside and root diameters have comparatively little to do with the actual fit; for, unless the angle and the lead of the threads are the same in both screw and tapped hole, and the diameters measured across the angles of the threads are relatively right, a proper fit can not be obtained, no matter how close to size the outside and root diameters are held.

Fig. 1 shows one effect of fitting together nuts and screws of different angles. In this case the screw is shown with a more obtuse angle than the nut, and the bearing between them, if one could be

obtained this way, would be on the sharp, fragile apexes of the teeth.

The necessity of measuring the angle accurately has led to the adoption of the term pitch diameter for screw threads, as well as for gears, and those who have gone carefully into the study of screw threads are using exclusively this method of measuring.

Fig. 2 shows a micrometer which measures these important diameters across the angle. The great merit of this particular tool is that it is not rendered inaccurate by the helix angle of the thread; that it will measure the finest lead thread as well as the coarsest within its range, and that it has the greatest range that has been developed.

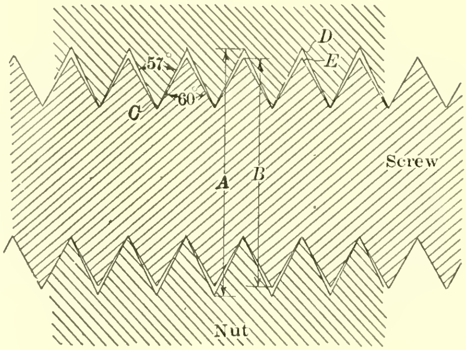


FIG. 1 EFFECT OF FITTING NUTS AND SCREWS OF DIFFERENT ANGLES TOGETHER

Fig. 3 shows how variations in the lead affect the pitch of a screw. The angle in this case has been assumed to be correct, but the nut has been tapped with a tap having long or stretched lead, with the result that a bearing can be had only in two places at the most, as indicated by *AD* and *BC*.

This is not by any means an exaggerated condition and explains the reason why a nut, tapped with a large diameter tap, will often start freely on a screw, turn a few turns, gradually becoming less free, and then bind. It has then found its *AD* and *BC* and cannot move further, because the position of the bearing on opposite sides of the thread acts as a wedge.

While it is possible that on small work and with soft metals, screws might be put together in this way, it is very evident that it

would not be a good job and would very soon prove unsatisfactory. It would also tend to place all the strain on one tooth at a time, making it possible, under a sufficient longitudinal strain, to strip one tooth after another with a shearing action, at a small percentage of the power that would be required to strip them all simultaneously when the lead is correct.

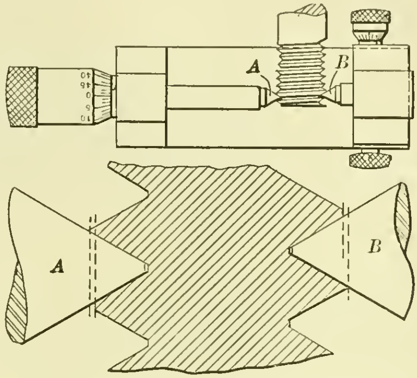


Fig. 2 Micrometer for Measuring Diameter of Screws Across the Angle

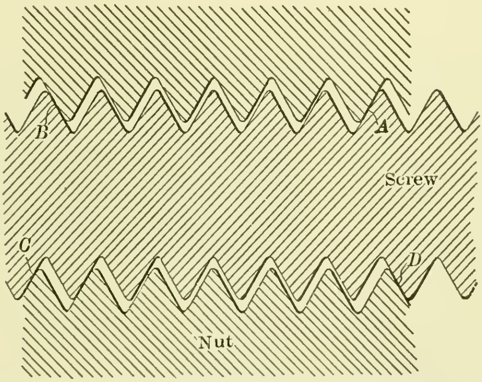


Fig. 3 Effect of Variation in Lead upon Pitch of Screw

As stated, the user generally desires only to have his screws and bolts fit satisfactorily. Those who do a large amount of assembling, where thousands of screws of various sizes are used, know the difficulty of this proposition. They are acquainted with the variation to be found in machine screws, as well as in the tapped holes, and with the delay which this makes in assembling, as well as with the

difficulty of supplying duplicate parts. For this reason, many are using point limit gages especially made to measure the screw diameters across the angles, and so insure the uniformity, within working limits, of the screws to be used.

Fig. 4 Point Limit Gage

Fig. 5 Screw carried down to Minimum Limit in Point Limit Gage

Fig. 4 shows one of these gages in use. The screw being measured has just been passed on the "go," or maximum limit, and with the same movement is carried down (see Fig. 5), to the "not-go," or

minimum limit. The screw being inspected in these two figures is evidently a good one, since it passed between the go, but will not pass between the not-go points.

The rapidity and accuracy of this method of measuring threads is partly apparent, but its great efficiency may be better realized if actual figures are given. An inspector of $\frac{1}{4}$-in. taps for limits on angle and outside diameters with two limit gages of this style, will gage about 750 per hour. For ordinary screw work, not requiring such extreme care, the output might be even greater.

As to the lead of taps, there is little doubt that most makers use a somewhat similar method to secure uniformity of product. It must be remembered, however, that as all steel expands and contracts with heat and cold, taps change their lead to some extent in the hardening process. If, in addition to this, they are warped on

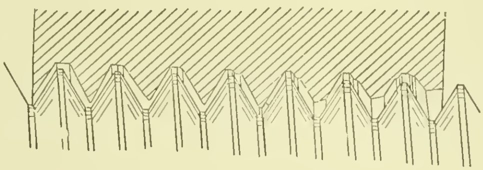


Fig. 6 Nut Tapped with Tap warped in Hardening—Standard Thread

the threaded end, the lead, the angle and diameter of the tapped hole will be affected, as can be seen in Fig. 6.

To what has been said of the effect on taps of errors in lead, angle, angle diameter and warping, must be added the effect of usage in reducing the size of the tap by wear, as well as the commercial variations of lead, angle and diameter in the screws or bolts, and it will readily be seen that under the best possible conditions there will be a multiplicity of minute errors that will have to be taken care of by the allowance between the minimum limit of the tap and the maximum limit of the screw. There will also have to be a maximum limit set on the tap and a minimum limit set for the screw, to provide for manufacturing allowances and to prevent too much looseness in the fit of the thread.

There is great diversity of opinion at the present time among tap and die makers, and screw makers in general, as to what these allowances should be, and what constitute the correct limits for the taps and screws of the U. S. Standard sizes, with the result that a buyer or manufacturer has trouble in securing taps to suit his screws, or

screws to fit his tapped holes, and is working under a serious handicap in his efforts towards proper fits and interchangeable work.

The Committee of the Society on the Standard Proportions of Machine Screws gave, in its report of 1907, a list of standard machine screw sizes, with diagrams and tables of standard proportions, limits for screws and taps, sizes of references, gages, etc., which received the endorsement of, and has been of unlimited value to, the industrial community at large. The question of limits for the larger size screw threads was, however, left unsettled, and this question, from its far-reaching nature, is too large a matter to be settled by either the manufacturer or the user.

In order to determine some of the conditions under which the tap has to work, such as proper sizes of tap drills, best lubricants, the correct cutting angles and shapes of flute, the right number of threads among which to distribute the cutting, the best methods of tempering to increase the life and strength of taps and prevent undue distortion and shrinkage, etc., Wells Brothers Company have had special testing machines built for showing the power required to drive a tap, and for recording the tap's cutting action on indicator cards or charts.

It is often found, in cases when one would least expect it, that a manufacturer is actually punching or drilling holes for tapping of a smaller diameter than the root diameter of the thread, so that the end of the tap must act as a reamer before the thread can be cut. In this case the tap becomes a taper reamer with unrelieved chip breakers, and reams a taper entrance to the hole. Oftentimes it will fail to "catch the thread" at all, and will therefore ream clear through or to the bottom without threading. Or, if the thread does happen to catch after reaming part way through, a short, weak thread is the result.

This requires considerable power, often beyond the breaking strain, and explains why taps sometimes refuse to cut a thread at all, and also why taps sometimes break almost as soon as they begin to cut. When it is remembered that, generally speaking, more than 80 per cent of the standard thread depth is never necessary in manufacturing, even for shallow holes, and in many cases not more than 50 per cent, the folly of having holes too small can be seen, and, in most cases, even of attempting to secure a full thread.

Tap drill sizes for machine screws in particular, should be varied according to the material to be tapped, and the depth of the tapping.

Roughly stated, for holes that have the screws enter more than $1\frac{1}{2}$ times the diameter, 50 per cent or half thread is usually sufficient, as the head will break off, or the screw will stretch or break before the thread will strip.

Soft, tough material, such as copper, Norway iron, drawn aluminum, etc., should have a larger hole for the tap than the harder and more crystalline materials, such as cast metals. This is because, if they are drilled smaller, the tops of the threads are liable to be torn off, which decreases the effective depth of the thread in the tap hole, and results in a poorer thread than if the hole had been originally drilled a little larger. On the other hand, in these more tenacious ductile materials, if the hole was originally a little large, the tap,

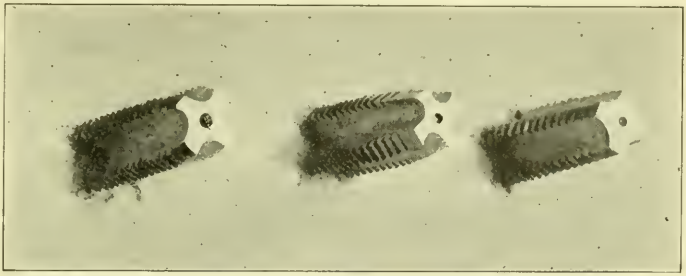


Fig. 7 Three Taps with Different Fluting

especially after the keen edge has become slightly dulled by use, will reduce the size of the hole by spinning or drawing the metal at the tops of the threads, thereby increasing the effective depth of the thread.

It should also be remembered that it is impracticable to tap a hole with the basic root diameter size, unless the much slower processes, with serial taps, or long step taps, are used, so as to divide the tapping operation into a series of successive steps, each removing a small amount of metal. The size of the hole also affects very materially the power required for tapping, and the tap breakage. This is particularly important in machine tapping, which is the main thing to be considered in manufacturing. The power is also affected by the kind of lubricant used, by the condition of the tap, whether sharp or dull, by the shape of the cutting edges and their effect on the shape and action of the chip, and also by the spaces allowed for chip clearance.

Fig. 7 shows three taps with different fluting. The tap at the

middle produces a long curling chip, which, in a deep enough hole, would have sufficient length to curl up tightly, jam the tap and cause the tap to twist or break off, if there was sufficient driving power. The chips are shown on Fig. 8. The length, the curled twisted form, and the large percentage of tightly curled chips should be noted.

Fig. 11 shows nuts in which long curled chips have rolled up and broken the tap. Note, however, the clean, smooth thread. As

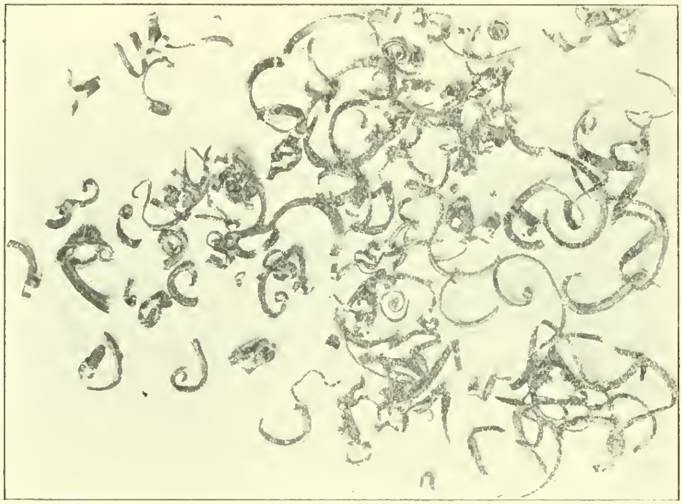


Fig. 8 Chips made by the Tap at Center of Fig. 7

shown in Fig. 7 the tap at the right tears and pushes the metal ahead of it, often accumulating enough compressed unseparated metal to resist further compression and break the tap. This tap broke while tapping cold-punched nuts, at 1100 in-lb., twisting off near the shank, in spite of the fact that the work was divided among 48 cutting teeth.

The chips from this tap are shown in Fig. 9. Their compressed character should be noted; in fact, they show by their appearance the relatively large amount of power and increased breaking strain required on the tap.

Fig. 12 shows the sections of four nuts tapped with this kind of tap, and in tapping which, the taps broke. The compressed and mashed-together mass of metal adhering to the thread, and the torn

condition, are noticeable When four of these obstructions accumulate in one tapped hole, one for each land, the tap is apt to give out.

In Fig. 7 the tap shown at the left not only cuts a free, slightly

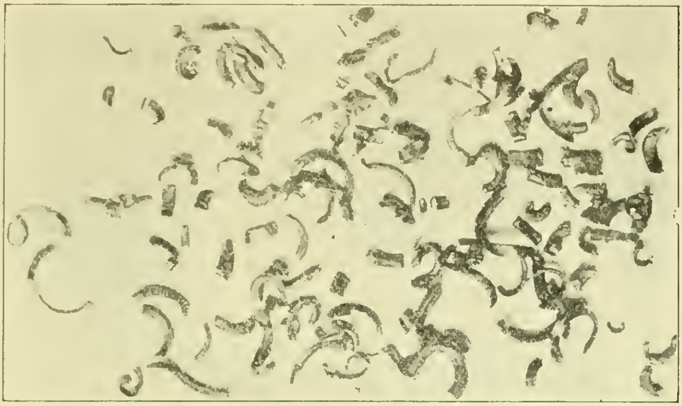


Fig. 9 Chips made by the Tap at Right of Fig. 7

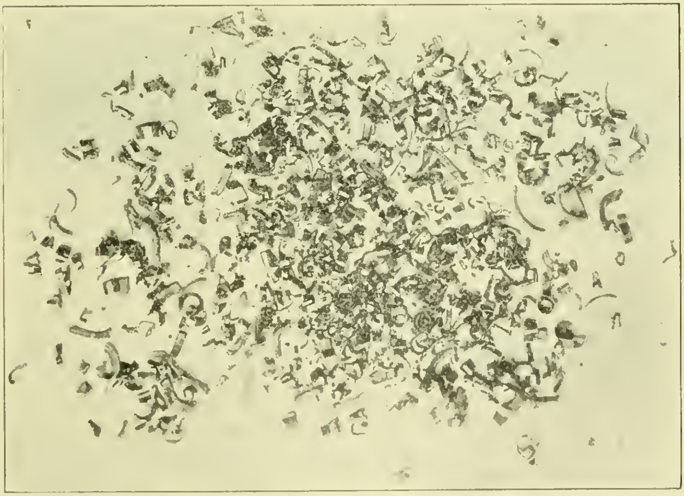


Fig. 10 Chips made by the Tap at Left of Fig. 7

curling chip, but will break the chip into short lengths that will readily slide out of the way along the flutes when pushed by the successive chips, or carried by the lubricant. It uses about one-third of the power, on an average, that the tap on the right does.

The chips cut by such a tap are shown in Fig. 10. They are free-cutting and short and the tap works under much less strain than with the other forms of fluting, as continued tests with different forms and in various metals have proved.

Fig. 13 shows a section of a nut in which this last style of tap was started and then the nut was cut open to show the action of the chip.

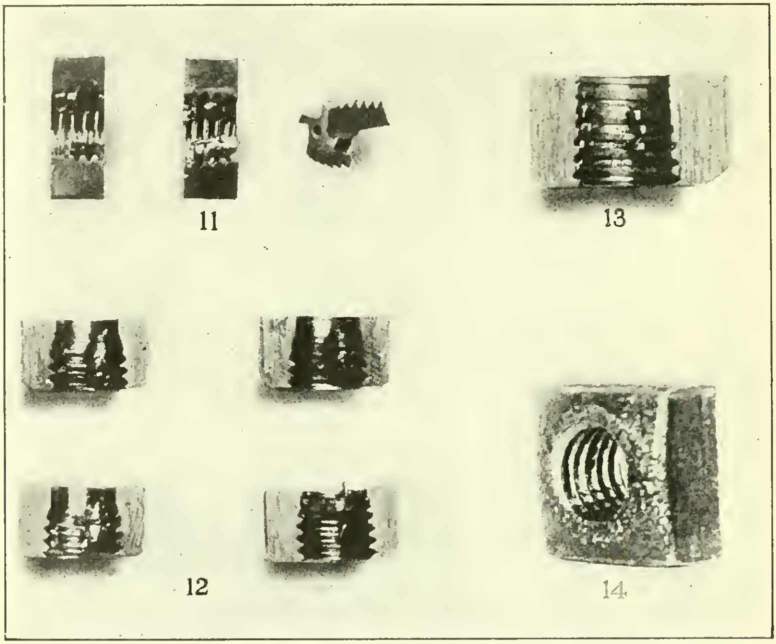


Fig. 11 Nuts in which Long Curled Chips have Rolled up and Broken the Tap
Fig. 12 Sections of Four Nuts Tapped with Tap Broken at 1100 In-Lb.
Fig. 13 Section of Nut where Chips are Broken into Short Lengths by Tap
Fig. 14 Chattered Nut

The smooth thread and clean, short curl of the chip which was on the point of breaking should be noted.

As almost all machine tapping is in through holes, and the uses of the bottoming tap are extremely few, experiments were made on the effects of sharpening or grinding the taps back from the end for a varying number of threads, so as to ascertain the effect of dividing the work among more or less cutting teeth. It was found by

repeated tests and careful record, that it requires approximately 25 per cent more power to drive a tap which has been ground back but four threads, which, in a four-flute tap, divides the cutting among 16 teeth, than for one which has been ground back six threads and having 24 cutting teeth. The 24 cutting teeth also gave much smoother threads, and cut more closely to size. This shows that for general use, a tap ground back six threads works better and will last longer than one ground back only four.

Fig. 14 shows a very badly chattered nut, the chattering being caused by burrs thrown up on the cutting edges of the tap during its manufacture; this has the same effect on the cutting edges of the tap that relieving or backing off the threads would have; that is, it cuts large and rough, and jumps from side to side.

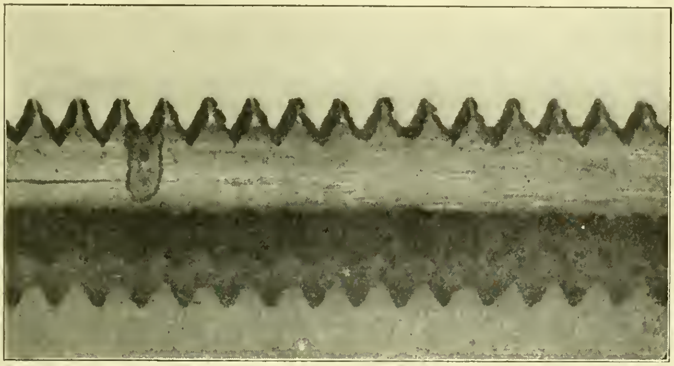


Fig. 15 Burrs thrown up on Cutting Edges of Tap, Causing Chattering of Nut

Fig. 15 shows a magnified view of these burrs. This shows the necessity of having taps free from burrs and great attention has to be paid to this point in order to produce good taps.

The effect of different materials upon the power required for tapping is shown in Table 1, which gives a chart of the results found on 14 different taps tested on test pieces of five different materials. The maximum and minimum power required by each tap when tapping consecutive test pieces is given in inch-pounds. It will be seen that drawn brass required, on an average, 65 in-lb. and is very uniform, and that while crucible steel is also a uniform cutting material, it required an average of 261 in-lb. or four times as much; cold punched hexagon steel nuts required an average of 190 in-lb.,

and hexagon screw stock, tapped endwise, 197 in-lb. Phosphor bronze shows the biggest power variation for the same tap, or throughout the test. It required an average of 228 in-lb. Taps Nos. 6 and 8 had a slightly poorer form of flute than the rest, and did not cut as smoothly nor as easily, as may be seen by referring to the power readings in the table

TABLE 1 VARIATIONS IN THE ACTION OF TAPS ON REPETITION TESTS IN DIFFERENT MATERIALS

TAPS USED ½ - 13 U. S. S. ROOT DIAMETER OF TEST PIECES 0.420 IN. DEPTH OF TAPPED HOLE 1½ IN.

	Test Nos. of Taps													
Materials used	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Hexagon drawn brass	60	62	62	60	65	70	60	90	60	60	60	60	60	65
	65	60	65	60	65	80	60	95	62	60	60	62	65	65
Crucible tool steel	220	242	250	230	240	280	250	375	210	270	260	270	260	258
	225	265	268	250	230	260	235	380	205	280	275	260	260	270
Cold punched hexagon steel nuts	148	158	168	170	155	150	150	340	165	195	165	175	148	180
	130	130	175	190	160	180	132	360	140	160	225	200	180	180
Hexagon screw stock	140	150	165	188	178	180	155	250	140	240	235	168	225	230
	160	170	185	165	210	268	170	430	155	190	200	160	205	205
Drawn hexagon phospor bronze	210	175	250	200	230	240	170	338	160	200	220	222	265	210
	190	200	300	250	200	250	182	320	190	330	210	245	205	210

The above values represent the power required in inch-pounds to drive the taps through the test pieces as measured on testing machine.

Table 2 shows the effect of varying the root diameters and using different lubricants.

In this table, which is the final result of a long series of tests, the breaking strain is taken for comparative purposes, as a 100 per cent strain (the power required to break a properly made ½–13 U. S. S. plug tap is approximately 1000 in-lb.), and the lesser strains required for tapping holes under different conditions are given as percentages of this. The test pieces used were common hexagon cold punched nuts accurately reamed to the respective drill sizes, and the taps used were regular stock ½–13 U. S. S. taps.

The points which this series of tests seem to emphasize particularly are as follows:

a That the lubricants used, up to a certain point, have the

TABLE 2 EFFECTS OF VARIOUS LUBRICANTS AND DIFFERENT TAP DRILL DIAMETERS ON THE CUTTING ACTION AND BREAKING OF TAPS

Lubricant	Animal Lard Oil, per cent	Sperm Oil, per cent	Graphite, 10 per cent Tallow, 90 per cent	Cataract Cutting Compound, per cent	Mineral Lard Oil, per cent	None, per cent	Machine, per cent
0.425 in. Diameter of Tap Hole, 75 per cent Thread							
Per cent of breaking strain	15.9	16.5	16.9	18.9	19.9	29.9	34.2
Breakages in tests	None	None	None	None	None	14	15
Quality of thread cut	Smooth	Smooth	Smooth	Smooth	Smooth	Rough	Torn
0.410 in. Diameter of Tap Hole, 90 per cent Thread							
Per cent of breaking strain	....	23	....	25.1	36.5	60.2	68.5
Breakages in in tests	....	None	....	None	None	50	71.5
Quality of thread cut	....	Smooth	....	Smooth	Smooth	Rough	Torn badly
0.400 in. Diameter of Tap Hole, 100 per cent Thread							
Per Cent of breaking strain.	....	35.5	....	41	57.5	71.8	100
Breakages in tests	....	None	....	None	None	66	100
Quality of thread cut	....	Smooth but with tops torn	....	Slightly rough with tops torn	Smooth but with tops torn	Torn and partly stripped	Torn and wedged so as to prevent tap cutting through

Note—By multiplying the above percentages by 10, the actual average power required in inch-pounds may be obtained.

same effect on the cutting power required as more or less metal to remove should have. For instance, to tap a $\frac{1}{2}$-in. nut with a 0.425-in. tap hole, using machine instead of sperm oil, would have practically the same effect on the power required, as reducing the diameter of the tap hole 25 per cent of the double depth of the thread. Referring to Table 2, it will be seen that the power is approximately double in both cases, from 16.5 per cent to 34.2 per cent on changing from sperm oil to machine oil, and from 16.5 per cent in the sperm oil column, to 35.5 per cent changing from a 0.425-in. to a 0.400-in. tap drill hole.

b That animal lard oil, sperm oil and the graphite and tallow mixture are the best lubricants of those tested.

c That a good cutting compound is better than some mineral lard oils for the purpose of tapping.

d That machine oil is a detriment instead of a help; that taps will cut better dry than with it.

e That the number of breakages can be greatly reduced by the use of a proper lubricant, and that taps should never be used dry in steel.

f That the diameter of the tap drill hole should not be any smaller than is absolutely needed to give the necessary strength, and that if this requires a full depth of thread on any particular size, it would be advisable, from a tapping standpoint, to gain strength by using a larger size of thread in combination with an over-size tap hole

g If for any reason it is desirable to produce a thread having the full depth, in order to prevent breakage of taps and the tearing of the tops of the threads (which ultimately increases the size of the tap hole), serial taps should be used with the best lubricant obtainable.

h That every decrease of 0.001 in. in the diameter of the tap hole, materially increases the power required to tap it, and also increases the percentage of broken taps; and that as the tap hole gets smaller, the power required increases and the breakages occur in increasing ratio.

Referring in Table 2 to the sperm oil column, it will be seen that the decrease of 0.015 in. in diameter from a 0.425-in. to 0.410-in. hole required only 5 additional in-lb. in power, or an average of a little

over 4 in-lb. per 0.001 in., while the decrease of 0.010 in. from 0.410 in. to 0.400 in. required 125 additional in-lb. increase in power, or an average of 12.5 in-lb. per 0.001 in.

In concluding the author stated that he had presented only a small part of the tapping proposition; and that the item of greatest universal interest among tap and screw makers and users in general is the question of the adoption of standard limits for the manufacture of screws and taps of the U. S. Standard sizes.

DISCUSSION

In the discussion which followed the reading of the paper, F. G. Coburn[1] stated that while on duty at the Mare Island Navy Yard, in California, he succeeded in getting the Navy Department to adopt the Society standard for machine screw taps and dies as well as that for machine screws; previously there had not been a single first-class, high-grade tap in the whole Navy Yard. There is one more important step to be taken in the case of machine screw taps, namely that of standardizing the shanks and shank squares. Now a great deal of time is lost, and confusion caused, because some of the machine screw taps will not go through the holes, the square or section not being of the right size. Something must also be done for the hand taps and tapper taps, dies for bolt machines, etc. A large loss is now caused by nuts bought from one manufacturer not going on bolts bought from another, or by tapper taps making in the nut machine nuts which will not go on a bolt drawn from the store room.

W. R. Porter described the method of measuring threads used by the S. S. White Dental Manufacturing Company.

George W. Adams[2] described the screw and tap situation in the Camera Works of the Eastman Kodak Company, at Rochester, N. Y. The particular requirements of the construction of the photographic camera demand a very high accuracy of the screw and enforce the use of a very fine thread. About 15,000,000 screws are produced, and while some of the screws run as large as 1.330-40, the screws used most are 0.060-90 and $\frac{1}{16}$-72, the former size being used principally on the shutter in which is mounted the lens. Mr. Adams sets the following limits on this 0.060-90 screw:

[1] Assistant Naval Constructor, League Island, Philadelphia, Pa.

[2] Eastman Kodak Co., Rochester, N. Y.

Minimum screw 0.059
Maximum screw 0.060

This allows 0.001 in the manufacture of the screws. The tap makers are allowed

0.001 over the basic for the minimum tap
0.0015 over the basic for the maximum tap

This gives 0.0025 between the largest tap and the smallest screw, and allows 0.001 wear on the minimum tap before the gage will be tight in the hole tapped.

It requires considerable attention on the part of the operator to hold these sizes, but Mr. Adams believes it to be practical. He has made some tests on taps in the past few weeks, and found that he could tap on an average 6100 holes through 0.040 sheet brass, which he considers to be a good record for such a small tap. No stream of oil is used on the tapping machines, as many of the parts are plated before tapping. This is done to prevent the nickel filling up the holes or decreasing them in size. In place of oil a special lubricant is used made by W. J. Foul, of New York. It resembles bees-wax in consistency, but Mr. Adams stated that he is experimenting with an air brush, so connected with the tapping machine as to throw a very fine spray just before the tap enters the work.

In the manufacture of small screws the dies play a very important part. The Acorn die was found to give the best results, with the die in many cases ground on the face, reducing the lead from 3 threads to 1 thread, so as to allow a full thread very close to the head of the screw. This has been found to be more efficient than using a small pencil and grinding internally on the edge of the teeth.

In closing his remarks, Mr. Adams called attention to the obligation laid upon the tap manufacturer to educate the public in the methods of measuring taps; to do this, information should be given in catalogues so that the ordinary workman in the shop can understand how to make a tap for a screw, and how to measure it. There are now many shops, and big shops at that, in which there are no suitable instruments for measuring taps.

E. Howard Reed said that he had found in many screw threads, especially in the nut, that the standard as adopted by the Society does not allow the manufacturer sufficient leeway. The machine screw nuts are made much thinner in proportion to the diameter of the screw than are the standard sizes of nuts, with the many frac-

tional sizes. On that account it might seem that it was much easier to tap the nut and get a full thread in it than it would be to tap a U. S. Standard nut. This is undoubtedly the case, but at the same time it is necessary to make the machine screw nuts very quickly. The price of the product does not admit taking much time in the process of tapping.

About $\frac{7}{8}$ full thread is put in, but so far no complaints have been received on account of the nuts being made with too little thread in them; in fact, that is as near as it is found possible to go commercially.

Horace K. Jones suggested the use of the following method for finding the outside diameter of a screw of a certain number, viz., to multiply the number by 0.013, and subtract 0.06.

Charles B. Russel [1] discussed the commercial value of adopting a U. S. Standard thread, and doing away entirely with the V-thread, to which end tap manufacturers have been working for a number of years. To determine the progress of the adoption of the U. S. Standard thread, the speaker looked up his sales of taps for the past year, taking the two types, the tapper tap and the ordinary hand tap, which are used by machinists for various purposes, and found 93 per cent of sales in the U. S. Standard against 7 per cent in the V-form. Letters from fifteen of the most prominent manufacturers of bolts and nuts, and of cap and set screws, have shown that the average output in bolts and nuts was 99 per cent in the U. S. Standard form of thread against 1 per cent in the V-form, which shows practically a complete adoption of the U. S. form of thread; in taps and screws, however, the output was only 53 per cent of the U. S. Standard form of thread against 47 per cent in the V-form of thread.

J. E. Winter [2] spoke of the trouble manufacturers sometimes have with customers who judge a tap by its outside diameter, mainly because the ordinary outside micrometer is the only instrument the manufacturers have; as a matter of fact, customers would get more wear out of a tap that is slightly oversize. As regards lubrication, cotton seed oil is both cheap and very good; if it is gummy when put on the machine, the application of a little kerosene oil will overcome that difficulty.

[1] Wiley & Russel, Greenfield, Mass.

[2] Winter Bros., Wrentham, Mass.

George B. Pickop suggested in regard to the adoption of U. S. Standard for thread diameters, that it would be a good thing to add to those diameters already established the standardization of the diameters of head and thickness of head, and width of slots in screws of the U. S. Standard, and also the length of thread cut on the body of the screw. These items ought to be fixed as well as the other diameters.

The V-thread cannot be abandoned on pipe threads, as the flattening of the top of the thread and the changes in the tap diameters and possibly die diameters might leave a space at the outside diameter which would present a starting point around the taps and cause leakages in the fittings.

F. O. Wells said that one of his experiments with an ordinary commercial tapper showed that it has a factor of safety of only 2 when new; when dull, he does not know what the factor of safety was. He had further found that a small shank tap is very nearly as strong as a large shank tap. He also mentioned that oil of some kind with a soapy body will make a difference in the size of the screw. With the same die there will be a difference of 0.007 to 0.008 in. between the sizes of a screw made with lard oil, and one made with a soapy compound.

C. B. Buxton[1] wrote that one of the greatest troubles of the present time is the question of obtaining the proper lead on screw parts, such as dies; this is not readily detected because the usual gages are not of any considerable thickness, but becomes very noticeable on many automobile parts, due to the internal member being threaded to such a length as to permit adjustment, and a screw that is cut to gage will not enter more than double its diameter before there occurs an interference, even when the tap cutting mating member is correct to pitch and lead.

On some alloys of aluminum, due to their peculiar character, the hole is increased, not by the cutting edges of tap, but by the natural flowing of the metal away from the point.

Table 3, while not entirely free from error, was compiled mainly from the condition actually observed of the thread after being tapped, and has been successfully used for five years.

[1] Tool Supervisor, American Locomotive Company, Providence, R. I.

Wilfred Lewis. The U. S. standard V-thread, flat top and bottom, should be adopted, I think, not only for pipe, machine and boiler work, but also as a universal world standard for all kinds of binding screws. I do not think this form of thread can be improved upon, but it is generally admitted that the U. S. standard pitches in

TABLE 3 SYSTEM FOR THREADS USED BY AMERICAN LOCOMOTIVE COMPANY

Size	Thread	Body Drill In.	Tap Drill for			Size	Thread	Body Drill In.	Tap Drill for		
			Steel Forging	Cast Iron	Aluminum				Steel Forging	Cast Iron	Aluminum
			Steel Casting	Malleable Iron	Brass				Steel Casting	Malleable Iron	Brass
4-36	V	32	42	43	44	1/2″-13	U.S.S.	33/64″	27/64″	Z	13/32″
4-40	V	32	41	42	43	1/2″-18	Fl.	23/64″	7/16″	27/64″	27/64″
6-32	V	27	32	33	34	1/2″-20	A.L.A.M.	33/64″	29/64″	7/16″	7/16″
8-32	V	18	27	28	29	1/2″-30	Fl.	33/64″	16/32″	39/64″	29/64″
10-24	V	9	23	24	25	9/16″-12	U.S.S.	37/64″	31/64″	16/32″	15/32″
10-32	V	9	20	21	22	9/16″-18	A.L.A.M.	37/64″	33/64″	1/2″	1/2″
12-24	V	1	15	16	17	9/16″-20	Fl.	37/64″	33/64″	1/2″	1/2″
14-20	V	1/4″	10	11	12	9/16″-24	U.S.S.	37/64″	33/64″	1/2″	1/2″
14-24	V	1/4″	6	7	8	5/8″-11	U.S.S.	41/64″	17/32″	33/64″	33/64″
1/4″-20	U.S.S.	17/64″	9	10	11	5/8″-18	A.L.A.M.	41/64″	37/64″	9/16″	9/16″
1/4″-24	U.S.S.	17/64″	4	5	6	11/16″-16	A.L.A.M.	45/64″	5/8″	5/8″	39/64″
1/4″-28	A.L.A.M.	17/64″	3	4	5	3/4″-10	U.S.S.	49/64″	41/64″	41/64″	5/8″
1/4″-32	U.S.S.	17/64″	7/32″	3	4	3/4″-16	A.L.A.M.	49/64″	11/16″	11/16″	43/64″
5/16″-18	U.S.S.	21/64″	1/4″	D	C	3/4″-18	U.S.S.	49/64″	45/64″	11/16″	11/16″
5/16″-24	A.L.A.M.	21/64″	H	17/64″	G	7/8″-9	U.S.S.	57/64″	49/64″	3/4″	3/4″
5/16″-32	V	21/64″	9/32″	J	I	7/8″-12	U.S.S.	57/64″	51/64″	25/32″	25/32″
3/8″-16	U.S.S.	26/64″	5/16″	N	19/64″	7/8″-14	A.L.A.M.	57/64″	13/16″	51/64″	51/64″
3/8″-18	U.S.S.	25/64″	O	O	5/16″	1″-8	U.S.S.	1 1/64″	7/8″	55/64″	27/32″
3/8″-24	A.L.A.M.	35/64″	Q	21/64″	P	1″-12	U.S.S.	1 1/64″	59/64″	29/32″	29/32″
7/16″-14	U.S.S.	29/64″	U	U	S	1″-14	A.L.A.M.	1 1/64″	15/16″	69/64″	29/32″
7/16″-20	A.L.A.M.	29/64″	36/64″	W	3/8″	1″-16	U.S.S.	1 1/64″	15/16″	15/16″	59/64″
7/16″-24	U.S.S.	29/64″	X	25/64″	W	1″-18	U.S.S.	1 1/64″	61/64″	15/16″	15/16″
1/2″-12	U.S.S.	33/64″	27/64″	Z	13/32″						

small sizes are too coarse, and I see no reason why the U. S. standard should not be revised.

An important advantage of the U. S. standard over the machine screw standard is that the former runs in sizes which can not be forgotten, while the latter runs in sizes which can not be remembered, and this difference marks the advantage due to a natural system of binary subdivision over a decimal system, with its long and short

jumps in spacing. Another point to be considered is the advantage of giving the odd sizes, as for example $\frac{9}{16}$ and $\frac{11}{16}$, the same pitch as the more common $\frac{1}{2}$ and $\frac{5}{8}$ sizes. Then, when a thread is stripped, a full thread can be tapped a little deeper in the same hole and an expensive casting need not be thrown away. At present this is seldom possible because the next size larger is generally of a different pitch.

The sizes $\frac{1}{2}$, $\frac{5}{8}$, $\frac{3}{4}$ and $\frac{7}{8}$, stepping up by $\frac{1}{8}$, form a group well spaced and convenient for all practical purposes between $\frac{1}{2}$ and 1, and to obtain larger or smaller standard sizes, I would simply multiply or divide these sizes by two. For instance, I would have $\frac{1}{8}$, $\frac{5}{32}$, $\frac{3}{16}$, $\frac{7}{32}$, $\frac{1}{4}$, $\frac{5}{16}$, $\frac{3}{8}$, $\frac{7}{16}$ for machine screw sizes, and split the differences for extra sizes which would have the same pitch as the next size smaller in every case. Between $\frac{1}{2}$ and 1, the extra sizes would be $\frac{9}{16}$, $\frac{11}{16}$, $\frac{13}{16}$ and $\frac{15}{16}$, and continuing to larger sizes, the standards would be 1, $1\frac{1}{4}$, $1\frac{1}{2}$, $1\frac{3}{4}$, and the extras $1\frac{1}{8}$, $1\frac{3}{8}$, $1\frac{5}{8}$, $1\frac{7}{8}$, having respectively the same pitches as 1, $1\frac{1}{4}$, $1\frac{1}{2}$, $1\frac{3}{4}$. Continuing, the standard sizes would run 2, $2\frac{1}{2}$, 3, $3\frac{1}{2}$, 4, 5, 6, 7, 8, and extra sizes could be added if desired. In this way there would be 25 standard sizes between $\frac{1}{8}$ in. and 8 in. inclusive with 24 extra sizes interpolated. The standard sizes would naturally fall into general use by reason of their simpler bases 4, 5, 6, 7, as compared with 9, 11, 13, 15, and the extra sizes would always be in readiness for renewal or repairs.

E. Howard Reed took up the causes operating for and against the general acceptance of the A. S. M. E. standard. The manufacturers have welcomed the definition of sizes and limits, the reduction of the number of pitches and the liberal allowance in setting limits of variation. Against it is mainly the existence of some previously existing standards which are held to by large users of machine screws. Foremost among these is the Pratt and Whitney standard which is used by the electrical industry. It is, however, Mr. Reed's experience that changes in the A. S. M. E. standard could be brought about more easily than seems to be imagined by those using other standards. This could be done for sizes where a noticeable variation occurred, by changing the size directly from one to the other, arranging as near as possible to use up taps, screws and parts to the existing standard before starting on that of the A. S. M. E., or, by comparing each standard, size for size, and gradually working the existing standard over by increasing or decreasing by small increments the limits of that size untill the A. S. M. E. limits were reached.

As to the manufacture of screw threads to the A. S. M. E. standard, the most important point is the placing of emphasis on the pitch diameter instead of on the outside diameter. This also is the principal point of difference between the cut thread and the rolled thread: while in the cut thread the outside diameter is determined by the outside diameter of the stock chosen, in the rolled thread there is also the shape of the die, the variation of the diameter of the blank and the adjustment of the rolling dies, all of these being factors in determining the outside diameter of the finished screw.

Once adjusted, the pitch diameter of screws produced by the thread roller remains constant during the life of the dies, while the outside diameter varies with the size blank on which the thread is rolled. This being the case an examination of the limits cannot fail to show how well suited the A. S. M. E. standard is for the production of rolled thread.

With regard to machine screw nuts, the application of the A. S. M. E. standard emphasizes a different set of conditions. Trade through long usage has been accustomed to a set of very coarse pitches: e. g., with $\frac{1}{2}$ in. diameter screws, 10-24 would be proportional to $\frac{1}{2}$-9, and 4-36 proportional to $\frac{1}{2}$-8. When you consider tapping $\frac{1}{2}$-8 or 9 and making full threads in steel nuts, you have the problem of manufacturing machine screw nuts. Even though these are proportionally thinner than fractional sizes, it is commercially impossible to tap a full thread, so that, from a manufacturer's point, the tap drill table in the A. S. standard will not give a working basis for punching or drilling nuts. Machine screw nuts with only half thread are generally speaking acceptable to the trade, and when they are apt to be used with screws of various standards it is possibly better that no attempt is made to tap full threads.

Luther D. Burlingame. For many years and from many directions there has been a call for an additional screw thread standard finer than the U. S. standard thread, not to replace the U. S. standard but to provide for other needs.

In 1885 Maj. William R. King read a paper before the American Institute of Mining Engineers on the subject of screw threads in which he took the ground that the U. S. standard thread is of too coarse a pitch for certain classes of work, claiming that the threaded bolt made according to that standard is weakened more than is necessary, and proposing a standard having an increased number of threads, thereby reducing the depth of thread.

In 1887 John L. Gill, Jr., read a paper before the Franklin Institute also criticizing the U. S. standard thread for certain classes of work and advocating a thread which would not cut so deep. He says, "To have a thread suitable for all kinds of work is not practicable," and for this reason he favors the adoption of an additional standard.

At the Boston meeting of The American Society of Mechanical Engineers in 1902, Charles C. Tyler presented a paper on "A Proposed Standard for Machine Screw Thread Sizes." This led to an extended discussion in which a number of standards were proposed all calling for finer threads than would be obtained by using the U. S. standard formula.

At the meeting of the Society in December 1902, Charles T. Porter read a paper entitled Finer Screw Threads. He said, "I have for several years felt a growing conviction that the pitches of our machine screw threads are far too coarse and ought to be changed. They reduce the area of the bolt unnecessarily. The Sellers (U. S. standard) thread made a considerable gain in this respect, but in the larger bolts the reduction of area is still two or three times as much as it needs to be. Again, the inclination of the thread permits the nut to be jarred loose easily. For these two reasons threads of a much finer pitch seem to be called for."

In 1902 a committee on screw threads, consisting of thirty members, was appointed in Great Britain representing the Institutions of Civil Engineers, Mechanical Engineers, Naval Architects, Electrical Engineers and the Iron and Steel Institution besides a number of other interests, and after making careful inquiries and holding extended conferences, the committee brought in a report advocating the addition of a fine standard for screw threads to be used in addition to the Whitworth screw thread standard. This to be called The British Standard Fine Screw Thread. In making the report the committee said, "Inquiries have, however, elicited a practically unanimous expression of opinions that the existing Whitworth series of pitches for screws from $\frac{1}{4}$ in. to 6 in. in diameter inclusive do not fully satisfy all requirements, and that where the screw thread is subjected to shock and vibration or extra strength is required in the core of a screw of given diameter, finer pitches are desirable.

"These facts led the committee to draw up the recommendation and table of standard sizes contained in this report."

In April 1906 the Association of Licensed Automobile Manufac-

turers of America adopted a standard having radically finer threads than the U. S. standard. In connection with their report the following statement is made. "During recent years manufacturers of fine machinery have found from experience that for a large portion of their work the U. S. standards for pitch of threads have been too coarse. . . . . In order to secure satisfactory construction special fine pitch screw threads have had to be made. The number and variety of these special threads have finally become such that great confusion, inconvenience and expense have been caused."

During the years 1905 to 1907 the matter of a standard for the small size screws was agitated by the Society and a committee, appointed by that body, formulated a standard which was adopted and which provides for fine threaded screws within the range from about $\frac{1}{16}$ in. diameter to $\frac{7}{16}$ in. diameter.

In June 1908 a report was presented at the annual convention of the American Railway Master Mechanics Association at Atlantic City, N. J., proposing a standard thread finer than the U. S. standard for special thin castle nuts. The report says, "There are, however, a number of large-sized nuts used on the locomotive, the thickness of which, on account of clearances, does not permit the use of the standard number of U. S. threads, and with the coarser threads there is liability of their working loose. To take care of such cases we have shown on plate 4 the number of threads per inch to be used on this class of nuts which will be known hereafter as the 'special thin castle nut.' These threads are finer than the U. S. standard and are practically the same as the threads often used for bolts in ship building construction where they are tapped into thin plates or are employed in places where thin nuts must be used."

During the same month that this matter was considered by the American Railway Master Mechanics Association, a paper was presented at the Detroit meeting of the Society by Amasa Trowbridge, entitled A Comparison of Screw Thread Standards in which he suggested the combining of the Society and the U. S. standards by making a new connecting link giving a finer thread than would be obtained by the U. S. standard for the $\frac{1}{4}$ in. to $\frac{7}{16}$ in. screw threads. After giving some study to Mr. Trowbridge's paper, it seemed to the writer that it was an opportune time to present for the consideration of the Society an intermediate standard to cover not only the need pointed out by Mr. Trowbridge but to meet the whole situation by extending the A. S. M. E. standard and producing

an intermediate standard which could be used in connection with the U. S. and with the A. L. A. M. standards, not with the idea of displacing either of these, but in order that the varying needs might all be covered with authorized and well established standards and thus reduce to a minimum the need of using special threads. With this thought in view, the writer worked out a formula and presented it at the Detroit meeting as a discussion of Mr. Trowbridge's paper. This formula gives threads practically coinciding with the adopted A. S. M. E. standard within the range for which that standard provides, and above that point is intermediate between the U. S. standard and the very fine pitches of the A. L. A. M. standard, thus meeting the needs of general machine work which would be better covered by a standard coming between these two extremes. It also provides for screws down to the smallest watch screws 0.01 in. in diameter, and also up to screws 6 in. in diameter, and gives results closely approximating the pitches used for screws by many leading manufacturers at the present time.

The fact that a thorough study of the situation by a competent committee in Great Britain has shown the existence of such a need gives confidence in urging that a similar need should be provided for in this country and it is hoped that steps may be taken to bring this about.

A. A. Fuller then read a discussion on the relation between angular diameter and lead.

By error in angular diameter, he said, is meant the difference between the actual and theoretical diameters as measured by a V-thread micrometer having a conical point on the measuring screw, and a V-anvil at the opposite end of the micrometer. By error in lead is meant the difference between the actual and theoretical measurements of two threads supposed to be 1 in. apart.

The desirability of uniform tapped holes is so apparent as to need no argument. With uniform tapped holes once established, a variation in the size of the screws, studs or bolts to fit the holes with any degree of tightness desired is a matter quite readily controlled. This analysis intends to cover only the most common uses of tapped holes, i. e., those that are intended to receive screws, studs or bolts for binding or holding together the parts of a machine or mechanism. These holes should be so nearly alike that for a given length or depth of hole a standard screw plug gage will fit in all the holes within an allowable tolerance in tightness.

Errors in angular diameter are easily comprehended and measured. An error of this kind produces the same effect as an error in the

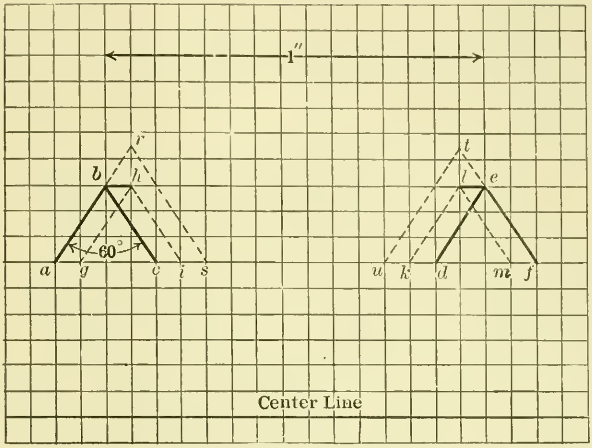


FIG. 16 HOLE TAPPED LARGE TO COMPENSATE FOR ERROR IN LEAD

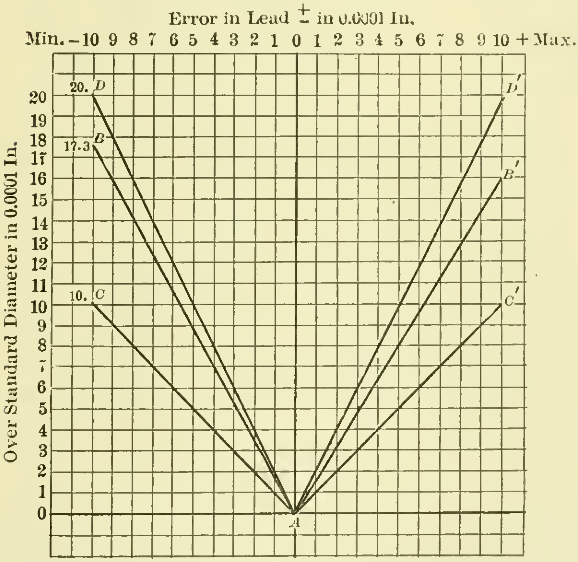


FIG. 17 RELATION BETWEEN DIAMETER AND ERROR IN LEAD FOR TAPS FOR HOLES 5/8 IN., 1 IN. AND 1¼ IN.

size of a reamed hole, i. e., it causes a variation in the tightness of the fit between the hole and the male member intended to fit the

hole. Within practical limits it is independent of the length of the hole, and the amount of variation allowable is inversely as the accuracy required.

Errors in lead are not so easily measured except by special machines constructed for this purpose, such as one made by the Brown

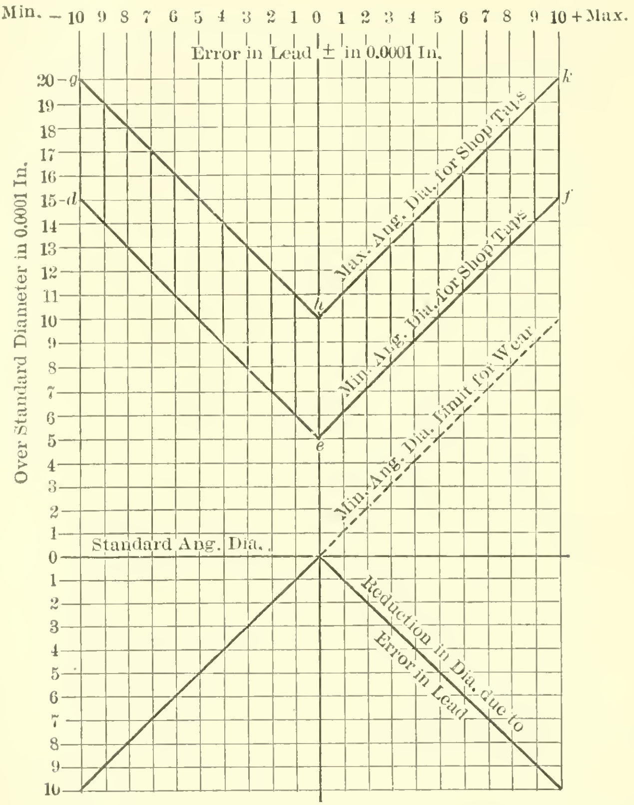


Fig. 18 Zone of Tolerance for Taps Class No. 1 for Threads 5/8 In. Long or under

& Sharpe Manufacturing Company. The effect of an error in lead is not direct. A plus error and minus error both produce the same effect as far as the fit of our standard plug is concerned, the practical effect of any error being a reduction in the size of the tapped hole, i. e., our standard screw plug will not enter the hole the required depth. Moreover, the amount of reduction is dependent on the

depth of the hole tapped. For a 60 deg. thread and a hole 1 in. deep it has a greater proportional influence on the diameter of the hole than the angular diameter, 0.058 in. error in lead equalling 0.100 in. error in angular diameter. The allowable variation in lead is dependent on the depth of the hole. For a short hole more error is allowable than a deep hole; but as it is more difficult to tap a long hole with less error than a short hole, in practice it is better to adhere to an allowable error in lead per inch and to compensate for that error by varying the angular diameter.

Referring to Fig. 16, let *abc* and *def* represent the theoretical position of two spaces one inch apart cut by a tap with correct lead. Let *ghi* and *klm* represent two actual spaces cut by a similar tap with an error in lead equal to $bh+le$. Then the stock *abhg* and *lmef* would interfere with the entrance of a standard screw plug. In order to remove this stock with a tap having the same error in lead, it would be necessary to increase its radius by the amount *rh*. The new spaces then cut would be represented by *ars* and *utf*, and the standard plug would bear along the surface *ar* as far as *b* and along the surface *ft* as far as *e*. Then

$$rh = \text{increase in radius}$$

$$2rh = \text{increase in diameter}$$

$$bh = le$$

$$bh + le = 2bh = \text{error in lead}$$

$$\frac{bh}{rh} = \text{tang. } 30 \text{ deg.} = 0.577, \text{ say } 0.58$$

$$bh = rh \text{ tang. } 30 \text{ deg.}$$

$$bh = 0.58\ rh, \text{ or } 2rh = \frac{2bh}{0.58}$$

$$\text{Increase in diameter} = \frac{\textit{error in lead}}{0.58}$$

In Fig. 17 the straight lines BA and $B'A$ represent this relationship.

If the depth of the hole is less than 1 in. it is necessary only to correct the diameter proportionally. On account of the lack of bearing, an error in lead is more objectionable than an error in angular diameter. If we assume an allowable tolerance of lead of +0.001 in. to the inch, then for a hole 0.58 in. deep an increase of 0.001 in. in diameter would just compensate for this error. The straight lines CA and $C'A$ would represent the relation between

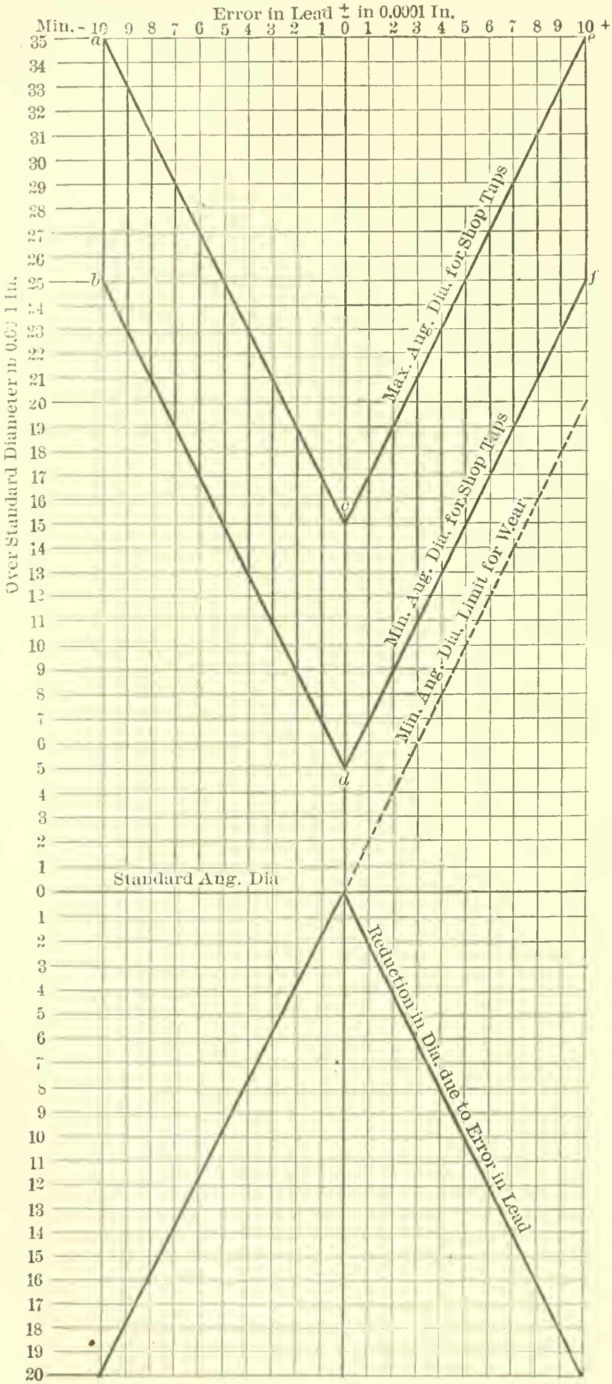


Fig. 19 Zone of Tolerance for Taps Class No. 2 for Threads $\frac{11}{16}$ In. to $1\frac{1}{4}$ In. Long

error in lead and increase in diameter necessary to keep the hole standard for a depth of 0.58 in. In practice it is desirable to have the taps slightly larger than standard. We can, therefore, move this line bodily upward a distance corresponding to 0.0005 in. and assume it to represent the relation between the error in lead and the *minimum* allowable angular diameter as shown in Fig. 18 by line *def*. Now, if we establish a tolerance in diameter of 0.0005 in. above this we have the line *ghk*, representing the relation between error in lead and maximum allowable angular diameter. The shaded area between these two lines represents the zone of allowable tolerance in lead and angular diameter that will produce tapped holes 0.58 deep within a variation of 0.0005 in. for practical running diameter. Without introducing any very great error, we may allow this zone to stand for all holes under $\frac{5}{8}$ in. in depth. As the majority of holes on automobile work are less than this depth, averaging, say, $\frac{3}{8}$ in. to $\frac{5}{8}$ in., this zone was adopted as a basis for inspecting all taps for holes under $\frac{5}{8}$ in. deep. Commercial taps were subjected to inspection to meet these requirements, and taps passing inspection were designated as Class No. 1 (Fig. 18).

By similar reasoning, the increase in angular diameter to compensate for error in lead for a hole *over* 1 in. in length must be greater than that for one 1 in. long, and for a hole 1.16 in. deep, an increase of 0.002 in. in angular diameter would have to be made to compensate for an error in lead equal to 0.001 in. to the inch as before. Assuming this as a standard, then in Fig. 17 the straight lines *DA* and *D'A* would represent the relation between error in lead and increase in angular diameter to exactly compensate for it on all holes 1.16 in. deep. Raising this line 0.0005 in. for a minimum angular diameter limit and establishing a tolerance of 0.001 in., we have in Fig. 19 a zone *abcdef* representing inspection limits applying to taps to be used on holes $\frac{11}{16}$ in. to $1\frac{1}{4}$ in. deep without introducing serious errors. Taps passing this inspection are designated as Class No. 2. Usually the diameter of the taps increases with the depth of the hole. Class No. 2 usually covers larger taps than Class No. 1. In like manner other classes could be established for deeper holes, or other classes for the same depth of holes with larger or smaller tolerances could be added. The only practical objection would be the difficulty of keeping them classified in the tool room and keeping track of them in the shop.

THE MECHANICAL HANDLING OF FREIGHT

By Samuel B. Fowler, Published in The Journal for January 1911

ABSTRACT OF PAPER

Lack of adequate terminal facilities, increase of net income and lower freight rates present problems the solutions of which are vital to the transportation company, shipper and consignee alike. Additional facilities are difficult to obtain, since there is usually no available land adjacent to the terminal or it is held at a prohibitive price. The capacity of present terminals can be increased by handling larger unit loads and moving them at greater speed, as well as by increasing the floor area by the use of freight sheds of more than one story. This is made possible by the substitution of mechanical devices for manual labor and hand trucks.

The terminal handling cost is a large item in freight charges. Mechanical handling methods will reduce the total transportation cost sufficiently to permit of a material gain in income, a decrease in rates, or possibly both.

The use of machinery will also bring about a new type of terminals and a revolution in present terminal methods, making possible other important economies. These economies are possible with team freight as well as l.c.l. freight, and with water-borne traffic as well as rail-borne traffic.

The problems thus presented should be worked out with a mind free from the bias caused by long familiarity with present practices.

DISCUSSION

DISCUSSION AT NEW YORK

L. De G. Moss[1]. Mr. Fowler's statement in Par. 20 is of great importance. At many important terminals, it is all but impossible to enlarge the area as a means to lessen congestion and delay, since a greater interest account, which is ultimately paid by the public, would result.

In Par. 10, Mr. Fowler gives the actual cost of rail-freight transportation, including operating expenses and interest on permanent way and rolling stock, as 3 mills per ton-mile. The revenue per ton-mile which is the cost to the users and paid for by them might preferably be given. This average cost per ton-mile in the United States

[1] Cons. Engr., 248 W. 131st St., New York.

is about 7.6 mills. The rate was 1 cent in 1888, with earnings of about $2300 per mile of track. Since 1898, the revenue has fluctuated between 0.763 cent and 0.724 cent and the earnings per track-mile have risen to over $3900. The length of haul is increasing, a potent factor in the reduction of rates. The ton-mile standard must be used with caution. Some Americans say with mistaken pride that freight carriage in England costs a little over 2 cents per ton-mile, ignoring the fact that the average haul here is about 5.5 times as long as in England. The comparison for equal hauls is not in our favor. Coal, which is readily loaded and unloaded, and moved in large quantities in cars which have a very low ratio of non-paying load, can be operated for 3 to 5 mills per ton-mile. Larger locomotives and trains, better cars and road bed, are all tending to increased earnings per mile of track, and to a reduction in the cost per ton-mile.

Turning to water-borne freight, coal is carried on the Great Lakes for about 1 mill per ton-mile under exceptionally favorable conditions, such as a specially designed hold which permits very rapid unloading, large unit cargoes, and the fact that the east-bound traffic consists mainly of iron ore and grain, while on the westward trip coal is usually carried. On the canals of New York State, which have not yet received the full benefit of the enlarged waterways and larger unit carriers, the cost is about one-third that of railway transportation. Coal is taken on the Mississippi River from Cairo to New Orleans, for 0.5 mill per ton-mile.. On long ocean voyages, say from London to Bombay, 10,754 nautical miles, the cost is about 0.6 mill per ton-mile.

Some American railways earn 1 cent per ton-mile; others fall to 0.5 cent, and find it difficult to operate with this slender revenue. Referring to Par. 11 of Mr. Fowler's paper, Mr. Byers, chief engineer of the Missouri Pacific Railway, analyzed the cost of terminal freight handling for 30 stations, as follows:

Labor and car shifting	$0.415
Fixed charges and amortization	0.286
	0.701

Many statistics fail to contain the legitimate fixed charges.

A common defect in existing terminals is that it is not possible in most cases to deliver or receive direct to or from wagons and teams. Team freight costs 4 to 8 cents per ton for handling, depending on the size, shape and weight of the packages. If the same materials are landed on the station platform and moved through the station to the car, the handling charge will rise to from 30 to 50 cents per ton.

There are two great difficulties to be overcome when mechanical transporters are used. Such devices must carry good sized loads to be economical. Therefore a skip or apron is needed for much of the freight received in light packages, and there must be a safe, clear space between cars, into which this skip can be lowered so as not to injure the sides of the cars.

If the box-car roof had a large hatch through which loads could be handled, the problem would be almost as easy as the unloading of flat cars if it were not for the fact that it would sometimes be necessary to unload cars under cover to exclude rain and snow from certain kinds of freight. The easy conditions can never be obtained that are met with in handling loose materials in gondola cars, which may be emptied from above or below, or tipped over by a dumper.

In some cases tracks could be arranged with island platforms, upon which packages could be delivered in or out, connecting the platforms by overhead cranes and telphers. Great skill would be demanded in their operation to avoid confusion between incoming, outbound, and transfer freight. These island platforms would also need a central depot where freight could be delivered, checked, weighed, invoiced, receipted for, and classified, before being sent out to one of the island platforms for storing. If the tracks and cars could be arranged to receive team freight direct, that would excel almost any mechanical device, except for very heavy loads, as long as box cars are used. These methods require expansion of area, which in turn means financial difficulties.

An obvious advantage to be gained by the use of gantrys, cranes and telphers, is in elevating a load to upper floors and in tiering packages. In England we find cranes of all types, operated by hydraulic or electric power, installed so as to serve practically any part of an important terminal. There geographical conditions make the typical terminal one in which both water and rail transportation enter; and a steamship dock, gantry cranes, railway tracks, teaming space, more railway tracks, platforms and freight sheds are found abutting on a driveway. The hydraulic crane, although safe and easily controlled, is giving way to the electric type, which is cheaper to install and to operate.

For marine terminals with mechanical equipment, Hamburg is the city to study. One dock alone, the Kuhwaeder, has over 130 cranes, the Municipal Dock about 100 cranes, the Free Haven, about 600. There are in all, about 1000 cranes, a few of which can lift 75 tons.

In the port of New York, aside from some good floating cranes, there

is only one pier equipped with cargo cranes, the Greenville pier of the Pennsylvania Railroad which has three C. W. Hunt unloaders, each handling 10 tons, with a large overload capacity.

Mr. Fowler points out in Par. 78 that comparing the cost of freight handling in San Francisco without machinery and Hamburg with its superb machinery, the difference in cost is but 10 cents per ton in favor of the latter. That looks small, but the multiplier is large. It enabled the city of Bremen to expend about $30,000,000 for harbor improvements and machinery, which was returned fully by the difference between the freight charges and cost of operation, and the increased traffic. In some cases, greater speed of loading steamers will not be of much importance, since the careful stowing of cargo below limits that, as well as the fact that as soon as many steamers are docked the "black watch" is engaged day and night, often with outside aid, in overhauling, adjusting and repairing.

F. B. Freeman.[1] In Par. 5 Mr. Fowler states that the inefficiency of the country's transportation service is strongly emphasized and emphatically stated to be due to inadequate terminal facilities. I believe that all the railroads will reply that it is a matter which is being rapidly corrected. Some years ago, when the great increase in traffic developed, the majority of the railroads had insufficient main tracks to move freight properly from one point to another. Main tracks therefore were the first point of attack, as is was not possible to obtain sufficient money to do everything necessary at once.

Now that the main tracks have been made adequate for the transportation of freight, the railroads are working on the development of their terminals and making them of sufficient capacity to handle all business offered them, with as little delay as possible. I think it safe to say that within a very few years this difficulty will be overcome just as completely as the inadequacy of the main tracks has been overcome. The matter is not going to be neglected and the railroads will meet all conditions just as rapidly as money can be obtained in order to carry out the improvements.

In Par. 6 Mr. Fowler states that the essential factor in the transportation costs is not that of handling the goods, but the expense of handling at terminal stations. In this connection it must be borne in mind that the excessive cost of handling freight at terminal stations, is due to the rehandling. The consignees practically all over the country have four days in which to take freight away from the

[1] Ch. Engr., Boston & Albany R. R., South Sta., Boston, Mass.

freight house. This means that each freight house has to be practically four times as large as is necessary for the handling of the daily business at the station. It also must have some additional area in which to handle freight which is not taken away, even within the four-day limit. This necessitates the rehandling of the freight in the house in order to deliver it to the consignee who arrives first. In Par. 7 he mentions the congestion of terminals, which is in a great number of instances due to the same difficulty, that all the consignees do not take away their freight promptly on its arrival. I believe that the cost of handling freight at outbound houses is not excessive for the reason that it is handled on the day that it arrives, i.e., the outbound freight house is practically empty every night.

In Par. 15 he states that the solution is the design of an entirely new system of terminal, adapted to the use of machinery. It should be borne in mind that all the old terminals which would be wiped out will still be a burden on the railroads, as they have been covered by bond issues, the interest on which would have to be met. This would all have to be borne by the freight charges in some form or other.

In Par. 23, item *b*, he speaks of tiering the packages in the freight house. To anybody who has studied the question of freight handling, it would be perfectly evident that tiering of packages in the freight house, no matter how accomplished, will lead to additional handling costs for the reason that in the majority of cases the lots to any one consignee are small. Should the goods be so tiered the probabilities are that the consignee whose lot is at the bottom of the pile will be the first to call for his goods. Supposing for instance, that in one bay of a house, there were piled 100 tons of freight. It is quite possible that there might be 20 or more consignees for this 100 tons of freight who would call for their particular consignments any time during the four days after they had arrived and had been stacked. This would necessitate, in all probability the moving of all the freight, in order to give each consignee his portion of it.

In this connection the only possible solution that there appears to be to the question at present, is to furnish sufficient floor space practically to pile the freight in consignment lots, so that it may be reached with the least possible amount of rehandling, other than that necessary for delivery at the moment.

In Par. 25 Mr. Fowler makes a statement that a single transporting machine, operated by one man, should be able to replace at least 16 truckers. In this connection the hand truck is practically a perfect machine for the purpose. With one man in the freight car, the man

handling the truck can pick up and take away packages of very considerable bulk and weight. With the mechanical operation of carrying increased loads which Mr. Fowler mentions, it would be necessary to put additional men in the freight car in order to move the material from the freight car upon the mechanical carrying device, whatever that might be. Where one man could move a package with the hand truck, it would probably take three or four men to move this same package from the freight car to the mechanical carrier, so that it would appear that the men taken off the truck would be simply turned into the freight cars, and no saving in cost in that connection would be made. The same line of reasoning would apply to the handling of goods in the freight house.

Referring to Fig. 1, Mr. Fowler makes the statement that considerable area would be saved with such a mechanical arrangement. Assuming for a moment that Fig. 1 has 11 tracks holding 10 cars each, and an average load of 20 tons per car, 2200 tons of freight could be delivered. It would seem that in any freight house the minimum space necessary to handle 1 ton of freight is about 25 sq. ft. so that therefore the freight house would require 55,000 sq. ft. to handle these 2200 tons of freight. Figuring on the basis of the length of tracks, it would be possible to make the house 600 ft. long, and it would therefore be necessary to have it 91 ft. wide. The availability of both sides of the house for trucking would give 1200 L. F. of trucking space. A layout consisting of tracks, intertrack platforms 25 ft. wide, driveway alongside the house and house delivery, would require about 250,000 sq. ft. On the basis of the present system a business of 2200 tons would require three tracks holding 37 cars each and a house 1500 ft. long by 50 ft. wide. This would give 75,000 sq. ft. for handling freight. It would also give 1500 L. F. for team frontage and the total area required would be about 150,000 sq. ft., or about 100,000 sq. ft. less property to do the same business than that which the mechanical layout would take, with 300 L. F. more space for teams.

It does not appear that more than one carrier could be worked to any advantage on each intertrack platform, so that if all of these tracks had to be worked together, there would be six mechanical travelers loading and moving on the trolley lines. It is fair to assume that at times all of these carriers would get into the freight house section at the same time and it would be inevitable that considerable delay would be caused to the moving of the travelers, so that the men in the freight house would be standing idle, as well as the men in the cars. With the present method of handling by trucks it can be so

arranged that there is no delay; it is a continuous movement, and with good management every minute of every man's time can be fully occupied.

In Par. 63, Mr. Fowler states that the freight-handling capacity of a given floor space can be doubled, if the goods can be moved twice as fast, from it or to it. This cannot possibly be done, since the freight has the right to lay on the floor for four days and it is absolutely out of the power of the railroad companies to expedite its movement. It has to stay there until the consignee calls for it. It is a fact that most of the congestion today at large terminal freight houses is due to the inability to get teams up to the delivery platforms. The mechanical arrangements would not appear to offer a solution to this feature unless there were an additional system of mechanical handling arrangements which would carry the freight from the freight house to the specially built delivery platforms. By constructing such platforms, sufficient accommodation could be made for backing up teams, but there would then be the delay in transporting the freight a considerably longer distance to deliver it to the wagons. There would be an additional burden of interest on capital cost for these loading platforms, which would be available for no other purpose. The interest on such investment would have to be borne by the freight.

In Par. 65 Mr. Fowler states that in many cases it would be possible to have packages piled on flatboards to be instantly removed from the teams by transporting machines. At large terminal freight houses, the number of times that this would happen would be negligible.

In a general consideration of this subject, it should be noted that the railroad companies are in a peculiar position in the matter of freight handling. They have to manage all classes of freight, all sorts and sizes of packages, under all kinds of conditions. In one car there might be a package of very small bulk that weighs a ton, and in the same car a package of immense bulk that weighs very little. These conditions seem to be met more fully by the use of the hand truck than by any other device yet brought to the attention of the railroad companies.

The various industries that are handling practically uniform packages, and which have an opportunity to grade them, do not appear to have adopted a mechanical system to any great extent. This is the first field for development of the mechanical handling of freight, and in view of the fact that the industries are not adopting this method where they have the incentive to do so and un-

doubtedly the most probable field for its success, it does not seem to me that much progress can be made in the handling of freight at railroad terminals.

J. P. Snow.[1] While I do not want to be understood as discouraging the mechanical handling of freight, I hesitate to approve the scheme described by the author as applicable to the general problem of handling L. C. L. freight. It is admitted that the terminal costs far exceed the transportation costs even for long hauls, but these costs are not all by any means between the wagons and the cars. The maintenance and operation of the yard and switching organization forms a large item.

The essence of the scheme proposed by the author is to introduce a carrying system between the wagons and the cars. Goods must be unloaded from the wagon, loaded on the carrier, weighed either before or after this loading, records made for billing, unloaded from the carrier after their journey and stowed in the car. As against trucking from the wagon over a scale and direct to the car, the truck leaving the package practically stowed, we have what amounts to an auxiliary transportation system with its two terminals, in lieu of the one simple handling by means of trucks.

The objection raised by the author to spotting cars is not of serious moment and is yearly becoming of less account for the reason that our cars are now being built to M. C. B. standard lengths. The days of freak cars are passing. The advantage of loading cars without moving them from where they are unloaded, as suggested by the author, is an ideal method that cannot be used until the millennium of single ownership is reached; so that cars need not be rushed back to their home road as soon as released from load. Even in passenger service, when the cars are of single ownership, it is not possible to make nearly so many train turns as it might seem. At a large terminal with 500 trains per day, only about 50 can be so turned without reshifting cars.

The true field of a mechanical handling device is where the material and movement is uniform and constant, as in a manufactory or where the distance of transport is considerable. L. C. L. freight, either coming or going, is not of this class under ordinary conditions. At a wharf or pier-head, where the tracks are at right angles to the vessel's berth it is difficult to reach cars enough by ordinary trucking

[1] Ch. Engr., Boston & Maine R. R., North Sta., Boston, Mass.

to receive a full boat-load; and here a telpher system may be used to advantage. It should carry the goods far enough into the yard to reach a point where cars can be readily shifted as wanted. More or less height of hoist is immaterial in a good telpher installation; hence for discharging vessels of various kinds it can raise or lower through hatches as well as transport to a convenient car platform, and its usefulness cannot be denied.

The author's suggestion that railroads deliver goods to consignees is well worth attention by our managers. An outfit of motor vans would seem to supplement properly the present somewhat incomplete equipment of railroads as common carriers. One serious trouble at freight terminals is the practice of consignees in refusing or neglecting to remove their goods promptly on arrival. If railroads did the forwarding, they could clear the houses much more promptly. This argument applies to team or bulk freight as well as to house freight.

J. H. NORRIS. During the past 15 years I have watched with interest the efforts of the Bush Terminal Company, Brooklyn, to handle freight. The property covers half a mile of water front and nearly a square mile of warehouses, and the proposition of handling the freight as it comes from the foreign and coastwise ships does not to my mind lend itself to the telpher system as described by Mr. Fowler.

The goods from ships are usually hoisted upon the dock and are piled according to their marks in lots for the examination and passing of the custom inspectors. These goods have to be sampled and weighed by the government and are usually re-weighed by the city weighers in the interests of the importers. Under these arrangements the requirements of freight handling are rather severe.

In the first place, a number of the goods are permitted and delivered direct to the importers' trucks on the dock; other goods are shipped in bond direct in cars or upon lighters; while other goods are taken to the warehouses and stored until wanted.

Fig. 3 shows the seven docks, each nearly 1400 ft. long, the warehouses and the railroad terminal. From this it will be plainly evident that a telpher system capable of handling freight would be so complicated and cumbersome as absolutely to prohibit its use.

After the incoming freight has been properly passed by the custom authorities and if it is to go into warehouses, the method of handling on these docks is to load it on small low trucks that have been drawn up to within a short time by horses or mules (Fig. 4), and to cart it to the warehouse to which it is assigned.

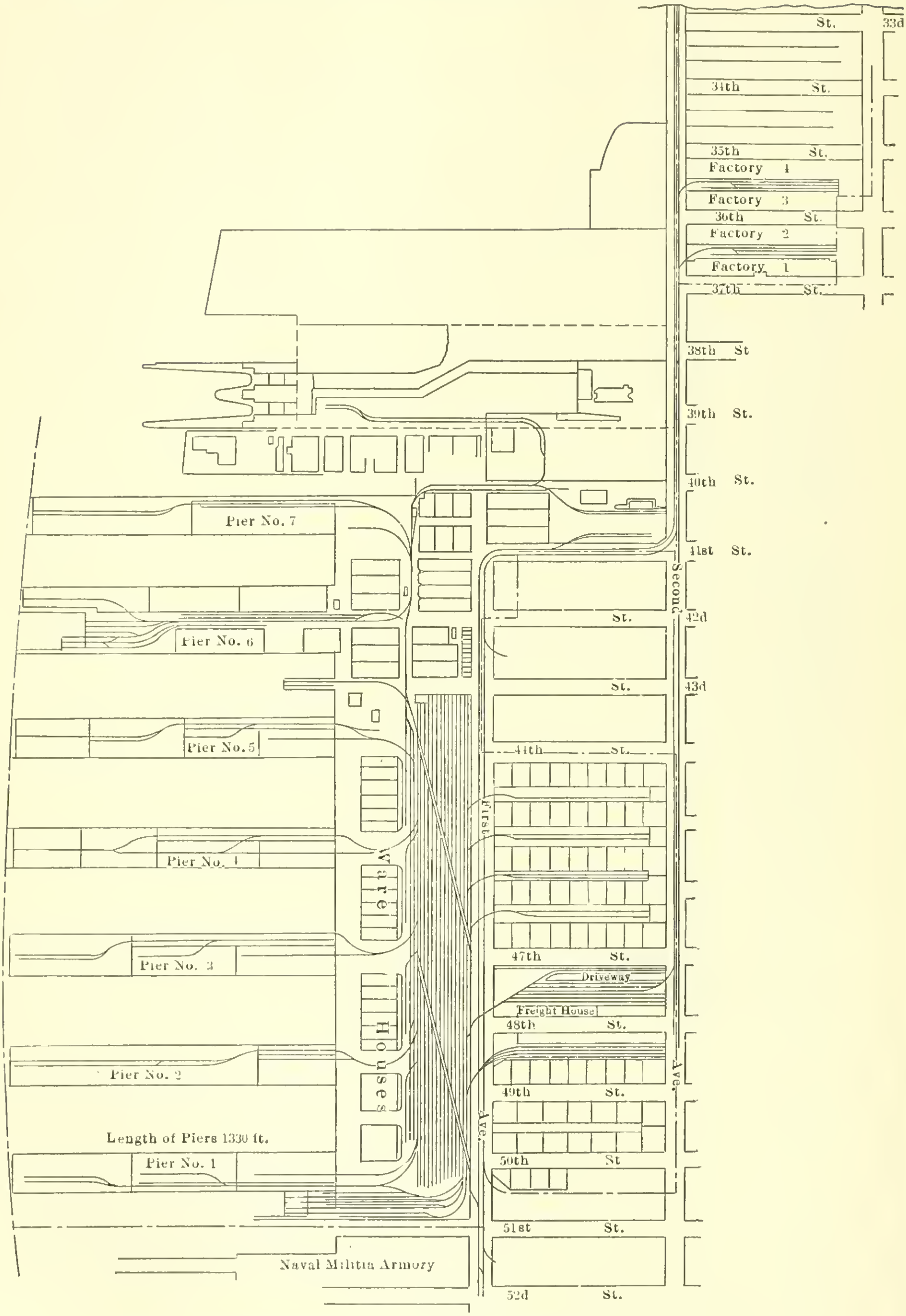


Fig. 3 Arrangement of the Bush Terminal, Brooklyn, N. Y.

The warehouses were originally equipped with elevators large enough to hoist these trucks to the floor desired, and a horse drew it to the proper section where it was tiered. Within the last year, however, they have adopted a storage battery truck (Fig. 5) which, while carrying a small load itself, can draw three of the other trucks and haul them to the desired position. Instead of elevators, electric hoists are now placed on the ground with ropes leading to blocks over the doorways in the warehouses and the goods raised and lowered in this manner. In addition to these fixed hoists, a number of portable

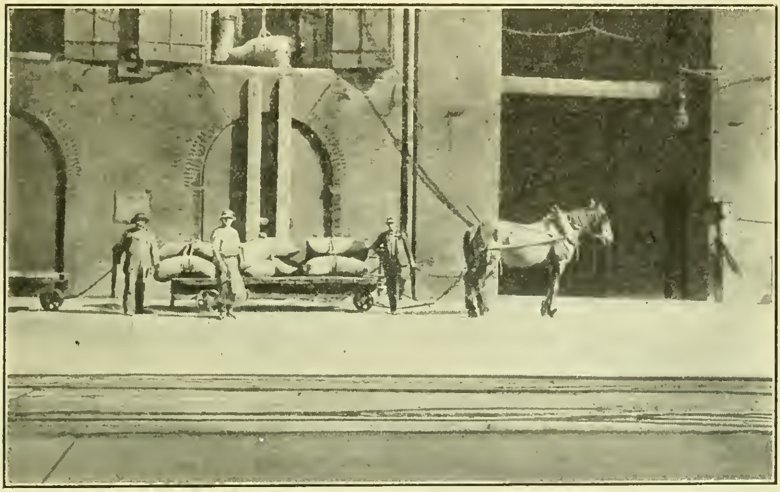


Fig. 4 Horse-Drawn Trucks in Use a Short Time Ago at the Bush Terminal

electric ones which can be hauled anywhere around the docks or warehouses are in operation.

Beside the general merchandise coming in on ships, large quantities of cotton, coffee and sugar are handled, and stored in the six-story warehouses along the river front. The warehouses in which the cotton is stored are one-story buildings divided into a number of sections by fire walls and protected by sprinklers. When the bales are received at the warehouses, they are tiered by electric hoists, the largest amount of storage capacity for a given amount of space being obtained in this way. Each of the warehouses has a siding in front of the door so that goods received by railroad can be placed opposite the warehouse in which they are to be stored, and handled with the least possible amount of labor.

As large a proportion of the outgoing freight as can be brought to the side of the steamer in lighters is so handled in order to leave the docks free for inbound freight. A great deal of outgoing freight however, comes in carload lots or in wagons and trucks and has to be sorted, counted and measured according to the bills of lading, being usually arranged on the dock in positions set aside for its port of destination if the ship is to make more than one landing. It is then moved in the most convenient manner to the side of the steamer so that the derricks can transfer it into the hold. The stevedores along the docks of New York handle freight of various styles and sizes in a

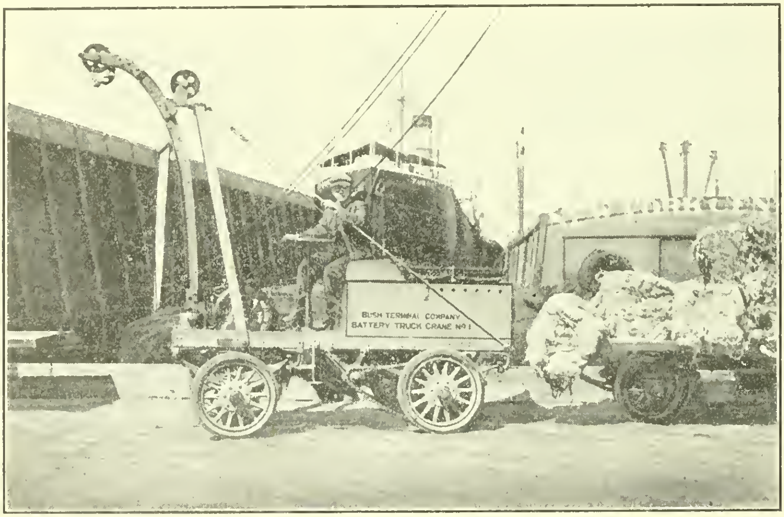


Fig. 5 Storage-Battery Trucks Now in Use at the Bush Terminal

manner that would surprise the uninitiated, not a single unnecessary movement being made by any of them.

In connection with the docks and warehouses is a terminal railroad with an exceptionally well laid out freight storage yard (Fig. 3). This concern also operates some model loft buildings that are rented for manufacturing and storage purposes. They are equipped with large elevators so that a manufacturer renting space can deliver the goods and receive a bill of lading at the door of his factory, the Terminal Company taking care of shipment, handling it on the elevators and into cars and making deliveries to manufacturers in the same way. This system is the most modern and convenient of which I have any

knowledge, and is similar to the one in use on the English railroads. In handling freight within its own property the Bush Terminal Company employs steam locomotives and where it uses the city streets electric locomotives. It also operates a trucking system for delivering freight in and about the city, consisting of gasolene-motor and horse-drawn trucks. In addition, it operates a marine department, consisting of tugs, car floats, lighters, both of the self-operated type, and barges.

H. McL. Harding.[1] In general it may be said that the handling of freight is an engineering problem depending more upon operation and operative conditions than upon the details of the construction of the conveying and hoisting machinery.

A number of important manufacturing companies are prepared to furnish from specifications, machinery that will fulfil the most exacting conditions of freight-handling service. It is, however, necessary to study and understand just how this machinery is to be combined and operated to perform all movements which are the result of long experience in freight transportation. These operating movements at an outbound station consist in unloading drays, assorting in piles according to consignments and classifications, inspecting, receipting, calling-out, weighing, scribing, routing, conveying, distributing, checking, car-stowage and re-checking. The following principles or rules comprise the essentials to the success of any such installation:

a No rehandling, as exemplified in the operation of tiering.

b To cover areas in the place of lines. The machinery to serve directly the whole floor space.

c Continuous rapidity of movements, as indicated by an unbroken main track and diverse paths.

Rehandling. In Par. 23 Mr. Fowler states, "The cost of tiering by hand is now prohibitive, it being equivalent to rehandling." Rehandling is fatal to any system of mechanical freight handling. This has been recognized by railway engineers and terminal superintendents, as well as by the stevedores themselves, and has, in the past, constituted the principal objection to mechanical methods. Mr. Calvin Tomkins, Commissioner of Docks, New York City, condemns rehandling in the strongest terms. In his report of December 16, 1910, in regard to the problem of transportation, he says: "And to this expense (meaning additional land) would be added the double hand-

[1] Cons. Engr., 20 Broad St., New York.

ling of freight in the terminal building and at the water front. This I believe is a fatal objection to such a plan. It was considered a fatal objection to a proposed tunnel plan which necessitated extra handling."

Some time ago the Pennsylvania Railroad engineeers were considering the installation of freight-handling machinery at one of their new Long Island terminals. A plan of overhead conveying was submitted to and approved by the consulting engineers, but the engineers of the railroad refused to install any overhead system which would require the rehandling of freight. The plan which had been submitted to them consisted of two side parallel main tracks with many cross-over tracks, which were to be placed so near together as to grid-iron closely the overhead space. The necessity of removing the freight from beneath the line after it had been lowered, thereby requiring rehandling, was to these engineers an insuperable objection. Their criticism was not in this case the large cost, but rather the theft, breakage and damage resulting from rehandling, which seemed to them to be of more importance than the additional handling expense.

At a transfer station in Pennsylvania, it was formerly the practice to remove the L. C. L. freight from the cars and place it in a large transfer house some 1200 ft. long by 100 ft. wide. When the cars were emptied, this house was filled with freight, which, after all the cars were unloaded, was redistributed so as to give the maximum load to each car going to different sections of the country. When a new superintendent took charge of the station, he transferred the freight directly from one car to another, without placing it within the transfer house, and effected a saving of $0.40 on every ton of L. C. L. freight handled, as well as reducing the time of transference. These figures were evidenced by comparisons between many monthly reports made before and after these changes were effected. Scarcely a ton of freight could be seen in the building after the change.

Similar examples can be obtained today in almost all important transfer stations. The amount of freight held or stored is generally less than 2 per cent, and this is chiefly due to errors in routing or breakage. Every transfer superintendent refers with pride to his present low percentage of rehandled freight.

Tiering. To tier successfully it is necessary to pile the boxes, bags, barrels and cases to a considerable height in order to utilize to the greatest advantage the space within the transshipment sheds. To give a specific example, a box, say 3 ft. square, is conveyed and

lowered by the hoist of the overhead carrier upon the floor, and next to this in line is placed another box, and so on, directly under the track of the overhead carrier. On top of this row it is possible to lower two or three more boxes, but above this there is a tendency for the freight to topple over. Upon either side of this first row of boxes, covering a distance often of 20 ft. to the right and left, it is necessary to place and tier other boxes. It may be seen, however, that in order to lower a second, third, fourth or fifth box by the side of the first, it is necessary to move the boxes by hand while they are being lowered or move them after they have been lowered. In some cases a rope or a hook is attached to the case or box as it is being lowered and it is pulled to the right or left of the space directly below the overhead line. This scheme is, however, clumsy, slow, congestion-producing, and is another form of rehandling.

Area Serving. Mr. Fowler in Par. 36, calls attention to the important subject of area covering or space serving. Closely allied with the subject of tiering is this provision for covering any and every square foot of floor area of the station or pier with miscellaneous freight without the expense of moving it after it has been lowered.

In this connection, the kind of receptacle for holding the freight when it is being transported is important. Flatboards, nets, barrel hooks and slings are some of the means employed today. At one Southern terminal the slings are left about the packages until they are again to be moved by machinery, thereby saving 75 per cent of the labor for this second movement.

Continuous Rapidity. The third important principle, continuous rapidity of the transferring movements, means that one train of four or five trailers, each with its own electric hoist, as explained by Mr. Fowler in Par. 60, should follow one another so closely as to be almost continuous, but at the same time should consist of individual train units, so that from the loading or unloading point or tracks they may pass along the main track without hindrance and to the loading and unloading tracks without stopping. According to the well-known practice of railway engineers, the main track must not be frequently broken where continuous operation is desired, otherwise the continuous rapidity so essential to successful freight handling will be impossible.

To show the necessity for continuous rapidity the following data from one station are of interest. The number of dray loads received at this station, only 216 ft. long, from 7 a.m. to 4.30 p.m., was 748.

Average lb. per dray	1732
Average number of packages per dray	18
Number of packages received	14192
Number of hand-truck loads	5702
Average number of packages per hand-truck load	$2\frac{1}{2}$
Average weight per package, lb.	91
Average weight per truck load, lb.	228
Number of lb-ft.	417,539,430
Number of ton-feet	208,769

More than half of this was received in about 3 hours. To handle such a number of packages within the time specified shows that there is no time for delays, and one load must follow another directly. This is not an exaggerated condition but, if anything, may be said to be below the average.

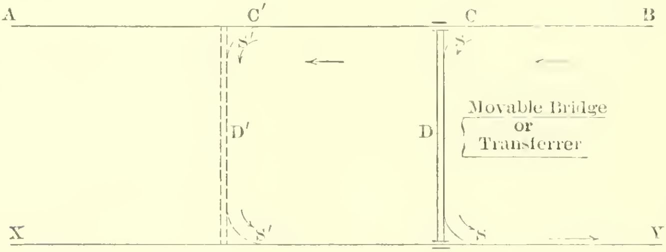


Fig. 6 Diagram showing Plan of Crane-Supported Track

Overhead Cranes. Numerous devices are used to obviate rehandling and to serve areas continuously, the best of which are slow indeed in comparison with the quick and numerous unit movements for freight handling. The traveling crane is one class of electric transfers excellently suited to shop work; but it is too slow and lacks the all-important factor, continuity, for freight service. If any machinery could be so adjusted as to retain all the well-known advantages of the crane, and in addition continuous rapidity, it would be the ideal system.

Acting upon this idea, noted by Mr. Fowler in Par. 52, crane makers, notably in Europe, have caused the traverser of the single-rail type of crane to pass from the tracks of the crane to and upon one side track, and by a loop to return to the crane from the other side. The great advantage of this scheme consists in the fact that there may be 20 traversers, each of which can move behind it a number of trailers with loads. The cross crane does not move with the load, it

is only to support a movable track. By making use, therefore, of the crane principle, allowing the traverser to pass upon the side track and having a number of traversers moving in circuits, always in the same direction, and running in trains with a number of hoists with tracks properly arranged, an ideal system with no rehandling, serving space and giving continuous rapidity is evolved. There may be several of these cranes, each carrying and supporting two or more cross tracks. This method is illustrated in Figs. 6, 7 and 8.

Referring to Fig. 7, *AB* and *XY* are the side tracks and *D* the movable cross or crane track, or as it may be called, a movable bridge track between the side or main tracks. *SS* are switches, whereby the carrier can pass from the fixed side to the movable cross track

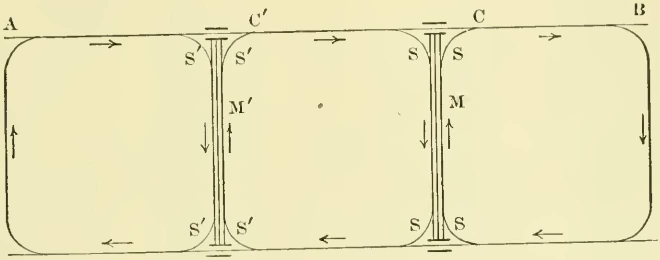


FIG. 7 DIAGRAM SHOWING ARRANGEMENTS OF MOVABLE CRANES, MOVABLE CROSS TRACKS, SWITCHES AND CONNECTING TRACKS

and also along the main side track by and beyond the cranes. *D′* is the position of *D* after having been moved.

Fig. 8 depicts two movable cranes, four movable cross tracks, switches and connecting tracks at the end. The direction of movement is indicated by the arrows. Loads, one after another, can be transferred with continuous rapidity by many transfer-hoists from any point within the side lines to any other point without rehandling. If the freight, after being deposited, is later to be moved, it is left upon the flatboards or in the slings, when it can be lifted by the overhead transfer hoist without any manual labor.

Fig. 9 shows another combination with diverse paths. The outer line of the two side loops may be outside a building, the walls of the building being within the closed loops, the curved ends of the loops

corresponding to the door openings or entrances. An example of this system may be found at the gas works in Brussels, where it is used to lift material from the purifying room below and spread it on any part of the regenerative floor, two traveling cranes carrying movable tracks being used.

At Bromberg, Germany, a traveling pedestal bridge is employed to support the movable loop track. By this means buckets of coal are shunted from the track running parallel to the building and dumped at any point in the storage yard, returning to the main track by the other side of the loop track.

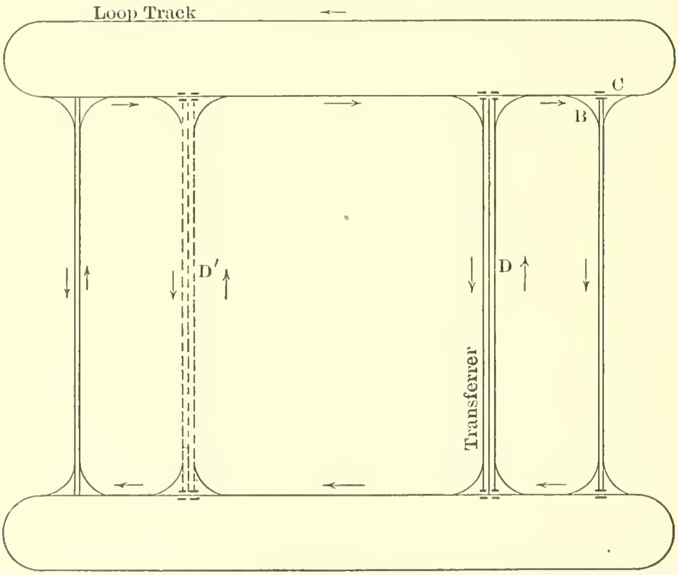


FIG. 8 DIAGRAM SHOWING COMBINATION OF CRANE-SUPPORTED TRACKS

It will be seen that terminal freight handling is a crane proposition, rather than one of conveying only, or preferably a combination of the two. It is also evident that line conveying is greatly limited and does not possess the same flexibility for terminal work as the area-serving crane modified and adapted to terminal freight handling.

A number of mechanical freight-handling plants are now being installed and projected by railways, chiefly in the West, as the Missouri, Kansas and Texas, in its new combined outbound, inbound and transfer freight station, in St. Louis, and soon it will be as difficult to find a hand truck as it is to find a horse car.

The essentials of successful terminal freight handling are, therefore, no rehandling, serving areas, and continuous rapidity in connection with the usual operating movements.

W. B. Waterman.[1] As Mr. Fowler has said, this problem of freight handling is one of terminals, and the solution is not to be found in the designing of new machinery, but rather in the *application* of well-known devices to the handling of freight, and the designing of an entirely new type of terminal suitable for use with machinery.

It is evident that if machinery is to take the place of hand labor, the unit load must be increased in order to increase the capacity of the station and warrant the investment. That is, instead of moving 250 lb. on a hand truck at a speed of 100 ft. per min., a load of 1000 lb., or more must be moved with machinery at a speed of 500 ft. per min. or faster.

It has been stated by railroad men and others that it is almost impossible, on account of the many classifications, to collect freight in order to obtain a larger unit load than is now obtained by a hand truck. This is especially true of outbound and transfer freight; the present practice being to take each piece or consignment separately, whether it is a small package or a piano, and truck it to the proper car. A truckman is not allowed to take packages for more than one car, as he cannot be relied on to put several packages in different cars.

It appears, however, that the solution of this lies in collecting the packages for any one car into one lot on the receiving platform, and transporting the collection by telpher to the proper car. This would give the desired increased unit movement. For example, assume the usual freight station accommodating 100 cars, as shown in Fig. 1. I would suggest a somewhat different arrangement of telpher runways, as shown in Fig. 9, the object being to provide a sufficient length of runways to accommodate enough telpher units for handling the tonnage of freight. The objection I find to layouts similar to Mr. Fowler's, and to a great many I have made and studied, is that the telphers are spaced so close together, they cannot move freely and accident or delay to one unit interrupts the entire system. In the arrangement shown in Fig. 9, each telpher runway over a platform forms a closed loop having a return path through the freight shed. There are, therefore, six independent telpher systems, each one tributary to the entire length of the shed, and each loop having two or three telpher

[1] J. M. Dodge Co., New York.

units as might be required to handle the freight. The total length of runways is 7300 ft. The telphers on any one loop can serve 20 cars, and 1000 tons per day can easily be handled by this system. There is not a switch involved in the operation to cause delay or interference. Nearly every square foot of floor space in the freight shed is covered, which, in the case of inbound freight would allow the contents of cars to be discharged and tiered over the entire area.

In the case of outbound freight, the idea is to have a space reserved in the outbound house of sufficient size to accommodate about 100 trucks or flatboards to be picked up by the telphers. Each one of

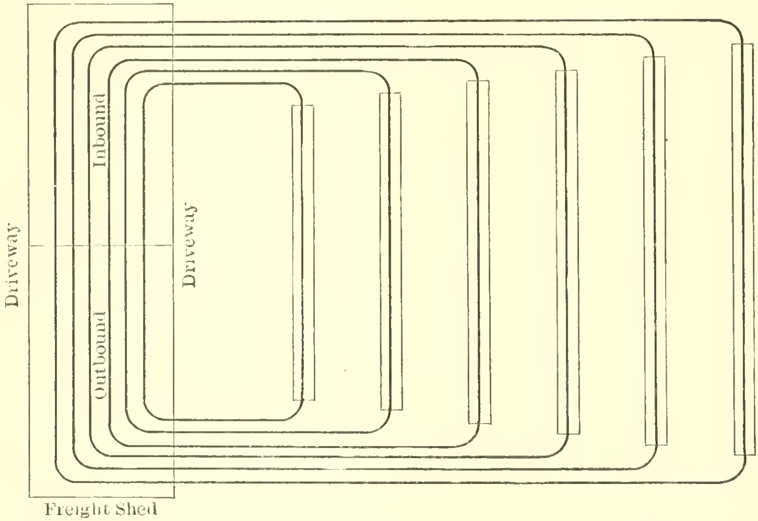


FIG. 9 DIAGRAM SHOWING ARRANGEMENT OF TELPHER RUNWAYS

these trucks would represent one of the railroad cars. As packages are received by dray, they would be weighed and checked and classified as usual and placed on the truck representing the car to which the freight was consigned. As soon as one truck was loaded with a sufficient number of packages, all for one car, it would be picked up by a telpher and set down near the proper car door. The next returning telpher would leave an empty truck in the space occupied by the one removed. All of the trucks would have designated locations under the proper telpher runways tributary to the cars they represent. The only hand trucking necessary would be in moving freight between drays and flat-boards, and this would be only across the shed.

The space occupied by these 100 trucks, assuming each 8 ft. long and 4 ft. wide, would be 3200 sq. ft., or a space 200 ft. long by 16 ft. wide. The floor space of an ordinary outbound house is about 20,000 sq. ft. It does not seem unreasonable to believe, therefore, that a proper terminal can be designed to take care of the proper number of trucks. In this way the freight can be allowed to accumulate on each truck until a sufficiently heavy load was obtained to warrant moving it by machinery, thus obtaining an increased unit movement.

While it would be desirable to eliminate all hand trucking and all rehandling, and to have the system cover every square foot of floor space and be absolutely flexible, it is not considered practicable at the present time to fulfil all of these conditions to the letter. That would mean the almost instantaneous evolution of a perfect system, such as there is no precedent for anywhere in the world. It is considered, possible, however, to approach these conditions so that perhaps 75 per cent of hand trucking can be eliminated, nearly all the floor space can be covered, and a sufficiently flexible system can be evolved (with some aid from the hand truck, which is a most efficient machine for short distances), which will greatly increase the capacity and decrease the cost per ton of handling, and which will warrant the investment.

W. J. Barney,[1] representing Commissioner Tomkins, of the Department of Docks and Ferries, New York City, spoke of the efforts being made to obtain better shipping facilities for New York City by assigning to railways the docks north of 23d Street on the Hudson River, thus providing much needed space for ocean steamships below that point.

This plan included the distribution of freight by an elevated railroad along the docks to the lower point of Manhattan Island. There are many mechanical difficulties to be met in connection with this plan, and Mr. Barney appealed to the members of the Society to come forward in a public spirited way as a number of engineers have already done, with suggestions for the solution of these difficulties.

Spencer Miller emphasized the importance of freight cars with movable roofs, so that the contents might be hoisted out by mechanical means. The Tehuantepec National Railway employs such cars, and hoists material directly from the cars into the hold of a ship by a complete system of cranes.

[1] Dept. Docks and Ferries, New York.

Mr. Miller also referred to the English system of freight shipment in which the railroad takes freight directly from the premises of the shipper by truck, and delivers it directly to the consignee in the same manner as is done by the express companies in this country. He believed that this method would prove economical to both shipper and railroad, because with carefully planned routes for the drays, it would be possible to have a full load almost continuously, instead of hauling a single package to the freight terminal, as is often the case at present. In addition, less storage space would be required with the entire control of the shipping process by the railroad company.

G. H. Condict[1] held that economical handling of freight is governed by three principles: continuous rapidity of movement, serving every foot of space, and no rehandling, and believed that by adopting a combination of methods now used in many manufacturing establishments, all of these features could be secured.

DISCUSSION AT BOSTON

E. W. Day[2] wrote that it was interesting to note the similarity of the system described in Mr. Fowler's paper to the following method to be employed by a large manufacturing concern for the handling of raw material. The apparatus was now in the process of construction and as yet untried. The problem was to handle inward-bound freight in the form of cases, casks, kegs, etc., and to store it in a warehouse of reinforced concrete 300 ft. in length and 80 ft. in width, served by a bridge crane of 75 ft. span throughout its length. The distance from the underside of the crane to the floor line was to be approximately 25 ft. The crane was to have a speed of 300 ft. per min., a trolley speed of 150 ft. per min., hoist speed 50 ft. per min., and a lifting capacity of 5 tons.

A sidetrack was to be located at one side of the warehouse for its entire length, openings being spaced 40 ft. on the centers to correspond to the length of a car, so that one spotting would place the car doors approximately opposite the doors of the building. A 10-ft. unloading platform, which was to be of the same grade as the floor and a part of the building itself was to intervene between the siding and building wall.

[1] Cons. Mech. and Elec. Engr., 20 Broad St., New York.

[2] Mech. Engr., Hood Rubber Co., Watertown, Mass.

A portable gravity-roller carrier was to be used from the inside of a car to the inside of the building. In order that cases might be placed on the automatic carrier with a minimum amount of hand labor 90-deg. reversible curves would be used inside the car. These cases would be delivered by gravity to the main floor of the warehouse, where they were to be weighed separately and, in many instances, unpacked to determine the net weights. They would then be repacked, placed on a platform having a rigid bridle, so that the crane operator could pick them up without help, and transported to any part of the warehouse. A number of these platforms would do away with any waiting either by the operator or laborers. The crane would also serve to bring the raw material to the point where it was to be started in process of manufacture.

In this scheme the four-wheel hand trucks were not to be dispensed with, since an overhead track system of the monorail type could not be found that would cover the ground as satisfactorily. Consequently a combination of the two methods would be used. The trucks were to be constructed in a manner such that they could be picked up by a crane or monorail-car operator and transported through various distances, in some cases 1000 ft. These trucks were also to be used instead of shelves, leaving the material stored to avoid rehandling, until it was ready for use.

With reference to the gravity carriers, Mr. Day believed they were destined to play a most important part in the handling of material and packages of all kinds. The ease and facility with which the portable types could be set up and operated even for a small number of parcels was worthy of note. The applications of these carriers in shoe-jobbing houses, wholesale houses, packing houses, brick houses, smelters and box factories had recently been investigated and in every case they were doing the work in an efficient manner at a saving of from 40 to 50 per cent over previous methods.

It had been suggested that the present way of teaming freight might be improved, and in this connection a removable automobile body or cage that could be placed by a crane on a four-wheel truck and delivered at the car door might be employed. By having several of these bodies an automobile could deliver one load at the freight house, load the empty body or cage and return for another. This would relieve the present congestion at the platform. It would also keep the truck, which represented a large investment, in operation a much greater portion of the time than is possible under the present methods.

This system, or something similar, is being used by the department stores of John Wanamaker and R. H. Macy in New York City.

D. B. Rushmore stated that electrical manufacturers in search of new applications for electrical machinery were giving considerable attention to the problems of freight handling. In the effort to reduce the cost of living there are few places in which so large a saving may be made as in this field. The problem must be studied from the standpoint of improving conditions in the many terminals which now exist, as well as the design of new ones.

The system described by the author has been in use for years in various modified forms but it has not found extensive use. A certain field of application may be found for it, but many of our great terminals would find it difficult to make use of the overhead telpher system because of lack of space.

In our large cities it is necessary to consider also the hauling of freight to and from the station. Signs seem to indicate that this will be done in New York and Chicago by underground subways. Electric vehicles are replacing the horse as a means of transporting freight in city streets and are of great help in facilitating the transmission of freight because they carry heavier loads and move faster. Another notable development is the recent adoption of baggage trucks operated by electricity at a number of important terminals.

The proposal to construct cars so that freight may be lowered in from the top is not a new departure in the handling of commodities, but simply an extension of the methods used in the department store and the factory for handling packages, and in the handling of ore, coal and grain.

R. H. Rogers[1] held that it was important not to underestimate the efficiency of the hand truck for handling freight. The truck is a lever of the first class, practically loads itself, may be transported up and down fairly steep inclines and when it reaches its destination a very simple movement unloads it and deposits the cargo practically in the space assigned to it. The stevedore and the truck form a complete unit with just enough brains to conduct the freight to the proper place.

With the telpher or similar systems it would seem that the extra time necessary to load the carriers over that for a truck, added to

[1] General Electric Company, Schenectady, N. Y.

the extra time needed to unload over that required for a truck, plus the additional distance it is necessary to go with a conveyor of this type as compared with the direct-trucking system, will constitute a handicap in time and labor that will be difficult to overcome with speed and large loads.

Mr. Rogers further expressed his belief that the average freight terminal with strings of cars side by side and connected by short gangways, is a very compact arrangement, permitting a trucker to go almost directly to the car for which his freight is intended. To make use of the transporter system, it is necessary to extend the yard and introduce a platform between each two strings of cars, with additional space if the first track is moved away from the station. Hence, there is not only a greater distance to travel because of the layout of the tracks, but also a greater area to cover.

Instances were cited by Mr. Rogers in which the cost of handling freight of various kinds ranges from \$0.07 to \$12 per ton and he also called attention to the fact that a great percentage of consignments are small, while many of the large ones must be broken up for shipment in different cars. Under these conditions it is difficult to make up the large units required for conveyance at low cost.

If all these conditions are considered, the present methods are more efficient than they seem to be. However, the difficulties are becoming greater and the time is approaching when nearly all of this work will be done by electrical or mechanical means.

F. W. Hodgdon[1] described the method used for handling raw sugar by the Spreckles sugar refinery of Philadelphia. The bags are discharged from the steamer down a gang-plank, and, after being inspected and weighed by the government, are carried over the wharf to the warehouse and piled up. The overhead telpher system in use 12 years ago is similar to that advocated by the author and seems to be the best for this class of freight, although it is suitable for any kind of package freight. Another advantage of the telpher system is that it provides more storage room for delayed goods.

Mr. Hodgdon also mentioned the difficulties of preparing and handling loads for the carriers and emphasized the necessity of loading cars by overhead methods.

R. E. Curtis thought that the journey of the package should not stop on the platform, but that mechanical means should be provided

[1] Engineer, Harbor and Land Commission, Boston, Mass.

for taking it from the car or placing it in the car without a stop. The business of a railroad is the selling of transportation, which should be done as promptly, directly and automatically as possible, and any break in the journey means loss in efficiency. Perhaps 20 per cent of the motive power used on railroads is engaged in switch service, and the casualties to men and property in railroad yards equal, if they do not exceed, those which occur on the road. Any saving that can be made in switching is, therefore, of great importance.

Three things must be done before it will be possible to attain the greatest efficiency: (*a*) the consolidation of transportation companies must be brought to the including of express drayage and other auxiliary transportation agencies, thereby eliminating much of the delay at various points; (*b*) a better method of grouping the smaller shipments must be adopted, either by improving the packages in which they are contained, or by some method of handling them to and from the cars in large quantities; (*c*) a free interchange of cars must be arranged so that the diversion and misrouting of cars may be eliminated. Although these improvements cannot be made immediately, progress toward the best efficiency must be in these directions.

J. P. Snow sympathized with Mr. Rogers and commended his ideas to anyone who was enthusiastic over the mechanical handling of freight, so far as railroad business was concerned. In reference to the alleged difficulty of spotting cars, he thought the tendency was now to build cars of uniform length, and when that desired end was reached, the spotting of cars would no longer be necessary.

Freight for a certain locality must be delivered by teams at a certain door. This brought the freight to the car in which it was to be shipped and the trucking distance was very short, especially if there were several lines of cars to load into—three, four or five, as mentioned in the paper—and the freight was transferred from the house into the cars very quickly.

In his opinion it was not advisable to store outbound freight. Shippers took no pains to ship their material in carload lots and fractional loads were bound to occur unless unreasonable delay was involved. He thought the idea suggested by Mr. Fowler that the railroad should operate vans to deliver freight to owners a good one and hoped it would be brought about sometime.

As to the mechanical handling of freight, it seemed best when adapted to water terminals where vessels lie at right angles to the track. At such terminals the tracks are necessarily dead-end. If

the vessel lies along the end of the wharf the freight must be tracked a long distance in order to get it into a sufficient number of cars, and it was difficult to make shifts and get the loaded cars out and the empty ones in if it had to be done while the vessel was being discharged. Some system like the telpher is splendidly adapted to these conditions and he thought that was the place for the railroads to try it.

For a layout of tracks and piers as shown by the author, he believed the storage battery trucks as used for baggage at many terminals were far preferable to an overhead-carrier system.

F. B. Freeman[1] called attention to the fact that the mechanical handling of freight at the railroad terminal is quite a different problem from that presented by a manufacturing establishment. In industrial plants, the packages are largely of the same kind, and can therefore be handled in groups and large lots. Such conditions are very favorable to handling by mechanical means. At the railroad freight house, however, practically every package, whether large or small, must be weighed separately, and immediately delivered to the proper destination car.

Under these conditions, it does not seem possible to handle large lots to advantage, nor can freight be tiered to any great extent, because it must all be accessible for prompt delivery to the consignee when called for.

G. H. Eaton[2] stated that as a traffic man he dealt directly with the public, and consequently received all the complaints. His experience in dealing with questions of delay had shown that the trouble is generally with the handling facilities of the terminals at intermediate points of transfer, rather than at the originating point. He also believed that the railroad should discourage the holding of goods in storage, rather than increase their facilities for doing so.

Most of the trucking at freight terminals does not exceed 25 to 50 ft., whereas, at water terminals, the distance is considerably greater and mechanical handling should therefore be first tried under these conditions.

G. T. Sampson[3] called attention to the fact that one of the first rules of railroading is: In case of doubt take the side of safety. This

[1] Ch. Engr., Boston & Albany R. R. Co., Boston, Mass.

[2] Genl. Freight Agt., Boston & Maine R. R. Co., Boston, Mass.

[3] Div. Engr., N. Y., N. H. & H. R. R. Co., Boston, Mass.

rule holds throughout the entire organization, and prevents or at least curtails the first adoption of new and untried methods. Where trains must be operated with unfailing regularity, the system for handling freight must be flexible. This is one of the strong points of the hand-trucking system, since it permits the shifting of men and trucks to suit the condition of the work. This system cannot be displaced until another method is found just as prompt and regular. Mechanical handling can only be fairly tried and tested in an extension to an existing large city terminal, where the kind and volume of traffic is regular and continuous, and by a corporation financially able to make the trial, even if it should prove unsuccessful.

Mr. Sampson believed that any successful system for the mechanical handling of freight must be as efficient as the cash-carrier system in a department store, and it must operate from the team to the car as surely as the small package containing the sales slip goes between the cashier's desk and the salesman at the counter. The real problem seems to be the design of a mechanical device, which will operate with the same certainty, whether loaded with a bulky single article weighing in hundred weights or with an accumulation of small packages.

Congestion of the incoming freight is due to the failure of the consignee to remove his goods promptly, and this forms one of the strongest arguments for the delivery of goods by the railroad with their own drays direct to the consignee.

G. E. Emmons.[1] said that during the past two years they have erected two large buildings which are to be used exclusively for storing material; one for finished apparatus, the other for raw materials. In both cases the buildings are equipped with tracks, overhead trolleys, single Coburn tracks, elevators, and in the case of the storehouse for finished apparatus, with an outside gantry crane which spans the space covered by two loading platforms. In common with others, they realized that there is a large expense involved in the handling of freight, and are doing all they can to minimize it.

[1] Mgr., General Electric Co., Schenectady, N. Y.

A COMPARISON OF AIR-BRAKING SYSTEMS FOR URBAN ELECTRIC RAILWAY CARS

A meeting of the Society was held in St. Louis on February 7, 1912, in which other engineering societies having representatives in that city were invited to coöperate. A paper on A Comparison of Air-Braking Systems for Urban Electric Railway Cars, by Charles W. Young and Charles A. Hobein, both of the United Railways Company of St. Louis, was read by the latter, describing the two systems, individual compressor and storage, commonly used for single cars in modern city service, with data on investment, operation, maintenance and depreciation costs.

The paper is confined to the discussion of the straight air system, as the only system used for single cars. This system allows the operator to admit air directly to the brake cylinder through the medium of an operating valve located in the motorman's cab. The release is likewise governed by the same valve. Two systems of straight air equipment are in use. In the individual compressor system the compressor is carried directly on the car and automatically maintains a constant pressure in the service reservoir, while in storage air systems the air is compressed to a high pressure in stations located in various buildings along the different car lines, and large storage tanks carried on the cars are charged by the use of street valves.

All equipment beginning with the service reservoir is practically the same with both systems. The service reservoir is a tank about 14 by 33 in. carried suspended underneath the car, and holding air for use directly in the brake cylinders at a pressure usually about 55 lb. The service reservoir is connected directly with the operating valve through suitable piping. Two types of operating valves are used: the Westinghouse valve, consisting of a simple slide valve operated by means of a rack and pinion, and the National Brake and Electric Company valve, consisting of two poppet valves, one for

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admission and one for exhaust, and a slide valve to govern the rate of admission of air and the rate of release from the brake cylinder.

It is common practice to make the shoe pressure equal to the weight upon the wheel. Theoretically it might be made about three times the weight upon the wheel, but it is impossible to train the motormen to make such practice safe from the operating standpoint. The standard brake shoes of the United Railways Company of St. Louis are made of cast iron with chilled inserts, run about 4000 or 5000 miles, weighing when new about 25 lb., and when scrapped about 13 lb.

The car compressor in the individual compressor system is of the single-acting duplex type, with the motor bolted directly to the compressor case, and is designed to have the full voltage applied when at a standstill.

TABLE 1 RELATIVE ADVANTAGES OF INDIVIDUAL COMPRESSOR AND STORAGE SYSTEMS

	Storage System	Individual Compressor System
Interest at 6 per cent	$18,803.90	$26,628.05
Taxes	3,463.20	4,906.00
Depreciation	17,835.97	34,172.66
Operation	105,276.60	70,820.11
Maintenance	32,884.92	36,750.52
	$178,264.59	$173,277.34
Investments	313,398.44	443,800.84

In adopting a system of air brakes there are several factors to be taken into account, such as first cost, which is often the determining. factor, total annual cost, and reliability.

Table 1 gives a summary of several tables presented by the authors to show the relative advantages of both systems from the standpoint of the original investor and operator. It is based on an air equipment for a total of 1372 cars.

From the report of the Electric Railway Test Commission it appears that the electric energy required to compress a cubic foot of air is 5.49 watt-hours in the storage system, and 3.99 watt-hours in the motor-compressing system. This results from the greater efficiency of the process of compressing the air directly to the pressure at which it is to be used. The difference between the electric energy used for braking in the two cases shows practically the same advantage

in favor of the motor compressor system, due to the fact that the air is more economically compressed, and delivered more economically to the brake cylinders. In the storage system more air is required from the fact that it is carried on the cars at a high pressure and leakage is difficult to avoid. In deciding upon the system to be used in any case, therefore, the question at issue is whether or not there is a saving in interest and maintenance in the use of the storage system which will offset the greater efficiency following from the use of the other equipment. The tests of the commission on the storage system in St. Louis brought out the fact that 95 per cent of the air compressed reached the cars.

In the discussion which followed the reading of the paper, Richard McCulloch[1] pointed out that the storage system can not be run economically on long interurban lines, but might be used to advantage in a smaller city of perhaps 50,000 to 100,000 inhabitants, where all the lines pass one point, especially if this point be in the neighborhood of a power station.

The following also participated in the general discussion: John Hunter, F. A. Berger, G. W. Lamke[2], A. S. Langsdorf[3], M. L. Holman, Jacob D. Von Maur[4], and L. C. F. Metzger[5]. The paper was illustrated by numerous lantern slides.

[1] Vice Pres. and Genl. Mgr., United Rwys. Co.

[2] Instructor Elec. Engrg., Washington Univ.

[3] Dean, School of Engrg., Prof. Elec. Engrg., Washington Univ.

[4] Supt. of Distribution, Laclede Gas Lt. Co., St. Louis, Mo.

[5] Asst. Engr., Terminal R. R. Assoc., St. Louis, Mo.

FOREIGN REVIEW

BRIEF ABSTRACTS OF CURRENT ARTICLES IN FOREIGN PERIODICALS

CONTENTS

FOREIGN REVIEW

The aim of the Foreign Review is to present, within the available space, the main data contained in the article indexed. Where possible, reference is made to English or American publications containing fuller information on the subject treated. Measures are given both in original units and their English equivalents. In many instances, engravings and tables are reproduced. Opinions expressed are those of the reviewer, not of the Society. Articles are classified as *c* comparative; *d* descriptive; *e* experimental; *g* general; *h* historical; *m* mathematical; *p* practical; *t* theoretical. Articles of exceptional merit are rated *A* by the reviewer.

Air Machinery

Compressed Air Hammer with Double Piston (*Luftdruckhammer mit Doppelkolben*, Seb. Schuster. *Der praktische Maschinen-Konstruckteur*, May 9, 1912. 1 p., 3 figs. and 1 plate of drawings. *d*.) Description of what is said to be the largest *compressed air hammer* in existence, built by Richard Herz Co., Vienna, Austria.

Air Filters and Their Industrial Applications (*Les Filtres à air et leurs applications industrielles*, R. T. Serrure. *Fer et Acier*, April, 1912. 6 pp., 10 figs. *d*). Description of existing types of *air filters*, and brief discussion of their application in metallurgy, electric plants, and for hygienic purposes.

Cost Accounting

Expense Burden in Mechanical Construction (*Les Frais généraux dans la construction mécanique*, L. Dubus-Delos. *Technique moderne*, May 15, 1912. 3 pp. *p*). The author is opposed to distributing the *expense burden* per-man-per-hour-of-work, but thinks that it ought to be distributed per tool, in accordance with the work done by it, and the expense actually involved. A tool setter's hour of work does not require as much expense burden as an hour of work of a man at a large lathe, owing to the difference in power consumed, depreciation of the expensive tool, room occupied by the tool, etc. (This is practically the same system as that proposed by Sterling H. Bunnel, *The Journal*, December 1911, p. 1557.) The article gives, as an illustration, the application of this method to the cases of two shops: one of 35, and the other of 100 men.

Firing and Fuel

Utilization of Coal-Tar Oil for Heating and Power Production (*Teerölverwertung für Heiz- und Kraftzwecke*, R. Hausenfelder. *Stahl und Eisen*, May 9, 1912. 11 pp., 20 figs. *dp*). The article is devoted mainly to the description of *furnaces and furnace appliances for burning coal-tar oil, naphthalin*, etc. The production of coal-tar oil rose during the last five years in Germany from 150,000 tons to 400,000 tons, and new uses had to be found for it: hence the experiments (now successful) with its use as a fuel. Its application is especially wide in metallurgical plants for puddling furnaces, mixers, Siemens-Martin furnaces, and for enriching blast-furnace gases where they are used for power production. It is also used in the Diesel motor (Cp. *The Journal*, June 1912, p. 909). The author is, however, against the use of raw coal-tar as fuel, because it contains up to 10 per cent. water which has to be paid for, carried, and freighted as tar, and which is useless, or even harmful, in combustion. It is further only a raw material, and contains valuable elements which may be extracted as by-products, but which are lost when the tar is consumed as fuel. The coal-tar is not well adapted to be used as a fuel, at least in the present furnace, because it is viscous, and apt to clog the nozzles; also, notwithstanding many experiments in this direction, it cannot be used in a Diesel engine with any reliability of operation.

Coal-Tar Firing plant constructed by Müller and Korte (*Die Teerfeuerung von Müller & Korte. Zeits. für Dampfkessel und Maschinenbetrieb*, May 17, 1912. 1½ pp., 2 figs. *d*). Description of a water tube boiler adapted for coal-tar oil firing, and data of tests of same. The coal-tar firing is a very important problem for the German engineers, owing to the large amount of this material obtained as a by-product of the gas and coke industries, and absence of local petroleum oil industry. In the tests it was found that the coal tar, with a heating value of 8236 WE per kg. (14,800 b.t.u. per lb.), evaporated from 9.3 to 9.65 kg. of water per kg. of combustible, the boiler efficiency being from 71.6 to 75.2 per cent.

Utilization of Hot Exhaust Gases from Blast Furnaces for the Production of Steam (*Die Verwertung der heissen Abgase von Flammöfen zur Dampferzeugung*, F. Peter. *Stahl und Eisen*, May 16, 1912. 6 p. *g*). The author refers mainly to puddling and reheating furnaces. The metal in these furnaces is heated in most cases to 800 to 1200 deg. cent. (1472 to 2192 deg. fahr.); in order, however, that the metal may reach such a temperature the temperature of the hearth must be considerably higher, and so must be the temperature of the exhaust gases. The efficiency of such a furnace is therefore very low, and may be expressed by

$$\varphi = \frac{t_a - t_e}{t_a}$$

where φ is the efficiency of the furnace, t_a initial temperature, and t_e final temperature of the hearth. For $t_a = 1400$ deg. cent. (2552 deg. fahr.), and $t_e = 1000$ deg. cent. (1832 deg. fahr.), the efficiency is

$$\varphi = \frac{1400 - 1000}{1400} = 0.29$$

or about 30 per cent, and even that is not the real efficiency, since the above

calculation does not take into consideration radiation and conduction losses.

The author goes fully into the question whether or not an attempt to utilize the heat of exhaust gases would interfere with the proper *working of the smokestack*, and finds that the weight of gases carried off by the stack remains, within certain limits, practically constant, notwithstanding some variations in the temperature of the exhaust gases. The cooling of the gases by the utilization of their heat for the production of steam will therefore not interfere with the working of the stack, provided that the draft of the stack is still strong enough to overcome all the resistances and to give the gases a sufficient velocity. Since in the majority of cases the draft is anyhow throttled by a damper, the utilization of the heat can have no ill effect on the working of the furnace.

If the boiler plant utilizing the heat could be constructed right on the reheating furnace, the efficiency of utilization would be

$$\varphi' = \frac{t'_a - t'_e}{t'_a}$$

where t'_a is the initial, and t'_e the final temperature. Taking usual conditions, the efficiency would be

$$\frac{1000-300}{1000} = 0.70$$

Actually, however, the *boiler plant* will not be *placed* right on the reheating furnace, but some distance away, and the efficiency will therefore be lower, probably about 60 per cent. The change in the total efficiency of the plant is therefore raised from 30 per cent theoretical to 80 per cent theoretical, or from about 20 per cent actual to more more than 60 per cent.

The next thing to be considered is the fuel and its utilization. It is very important in a reheating furnace that the gases have a certain composition, so as not to injure the metal by excessive oxidation. This makes it preferable to admit to the furnace too little rather than too much air, loss of fuel due to incomplete combustion being preferable to possible loss of the metal due to excessive oxidation. The amount of this loss of fuel depends on the construction of the furnace and conditions of operation, but the author has found in one case not less than 6 per cent of carbon monoxide in the exhaust gases of a reheating furnace, while M. Phillips (*Stahl und Eisen*, January 4, 1912, p. 12) found as much as 9 per cent carbon monoxide in a semi-producer type furnace exhaust gases.

The use of exhaust gases for the production of steam is more economical than for preheating feedwater or superheating steam. In the first case the difference between the temperature of the gases and water is great, and either only part of the heat in the gases will be used, or a very large amount, more than is required in a steel plant, will have to be preheated. Superheating of steam by exhaust gases can be easily done, but its economy is impaired by the fact that the working of the furnace does not always happen at the rate that steam is wanted. With a slight demand for steam it may be superheated too much, while the opposite may happen when the demand for steam is too large. The article is to be continued.

Internal Combustion Engines

Report of an Investigation of a Peat-Gas Plant of the Görlitz Machine and Foundry Company (*Bericht über die Untersuchung einer*

Torfgasanlage der Görlitzer Maschinenbauanstalt und Eisengiesserei A.-G., H. Baer. *Zeits. des Vereines deutscher Ingenieure*, April 6, 1912. 4 pp., 12 figs. *de*). Description and data of tests of a *Görlitz peat-gas producer and gas engine*, with drawings of the latter (for a full description see *Zeits. des Vereines deutscher Ingenieure*, 1911, p. 368 ff., Heinz Die Ausnutzung unserer Torfmoore). The most interesting part in the construction of the producer is the care taken to prevent the escape of heat, which is very important in this case owing to the considerable consumption of heat in the evaporation and decomposition of the water in the peat. Air is introduced into the producer in two streams, one through the producer jacket so as to take up the heat of radiation, and the other in such a way as to be strongly preheated by the gases produced. The arrangement is so efficient that during the tests at the East German Exhibition in 1911 in Posen the cylinder jacket and gas outlet pipe were found to be only handwarm. The tar-containing parts of the fuel are consumed in the producer itself, while the gases of incomplete combustion and products of distillation are generally forced to pass through the zone of incandescence instead of being allowed to escape through the gas outlet pipe.

The analysis of the peat gas shows it to contain 23 to 25 per cent of moisture and about 4 per cent of ashes. The remarkably low percentage of moisture is said to be due to the hot and dry summer of 1911. The average heat value 3949 WE per kg., or 7128 b.t.u. per lb. Two tests of 8 hours 3 minutes and 8 hours 11 minutes were made, with the following results as to the consumption of peat, and cost of power:

TABLE 1 DATA OF TESTS OF A GÖRLITZ GAS PRODUCER PLANT

Number of Test	1	2
Consumption of peat per kw-hr. at the switchboard, kg	1.555	2.41
lb	3.41	5.3
Consumption of peat per effective h.p.-hr., kg	0.99	1.45
lb	2.19	3.19
Consumption of peat per i.h.p.-hr., kg	0.82	1.16
lb	1.80	2.55
Fuel cost per kw-hr., at the switchboard, pf	0.62	0.965
cents	0.15	0.26
Fuel cost per effective h.p-hr., pf	0.396	0.580
cents	0.9	0.14

While the first cost and attendance are said to be about the same as in the case of a steam plant, with at least equal reliability of operation.

Improvement of Internal Combustion Motors Through Preheating of Air (*Verbesserung von Verbrennungsmotoren durch Vorwärmung der angesaugten Luft*, A. Nougier. *Die Gasmotorentechnik*, May 1912. 2 pp., 1 fig. *dt*). Translation of the first part of the article in the *Génie Civil*, February 24, 1912, under the same title, fully reported in *The Journal* for April, p. 615. Attention of those who may use the original French or the above German translation is called to the error in the heading of the

third column of the figure, where the exponents of $\frac{p_1}{p_0}$ and $\frac{v_0}{v_1}$ are omitted. They are correctly inserted in the *Foreign Review*.

AUTOMATIC SPARK ADJUSTMENT (*Selbststätige Zündverstellung*, Löw. *Zeits. des Mitteleuropäischen Motorwagen-Vereins*, End April, 1912. 2 pp. *gh*). The first automobiles had no spark adjustment. Benz was the first to introduce it, but placed it so that the driver, to change the spark, had to open the back cover, after having previously stopped the motor. One of the reasons why the spark adjustment was not placed directly at the driver's seat was that the old motors had a great many more levers than the present ones, and the designer was naturally unwilling to make it look still more complicated. Fiat was the first to introduce a centrifugal spark adjuster, but took it off shortly after, so that the regular use of automatic spark adjustment dates really only from 1910, when its application was made commercially possible by the introduction of Eisemann's magneto.

What the centrifugal spark adjuster does is to advance the ignition at high speed, and retard it at low speed, so that the purpose of the adjusting device is to insure the *most advantageous time of ignition*, but the most advantageous time may mean either the time which insures the most economic working of the motor, with the least consumption of fuel, and minimum stress of its parts, or it may mean the condition under which the output of the motor is at its maximum. These two things are by no means identical, and while the driver may want, under certain conditions, to get out of the motor all it can give, he will regularly try to run it as economically as possible. But the automatic spark adjuster can regulate the adjustment only one way, and adjustment by hand is therefore more flexible.

A further disadvantage of automatic adjustment is its aptness to get out of order. The governor springs change in tension, the revolving parts get out of balance owing to the shocks and vibrations, and as a result the time of ignition is displaced, often very disadvantageously, the worst feature being that it is very difficult to discover whether the ignition is really set as advantageously as believed. Even when the ignition was set at the factory and carefully tried, there is good reason to believe that it would have to be changed after a few weeks of actual work on the road; but whether it is so, and just how much it has to be changed, can be found only by new careful tests, which the ordinary automobile owner is either quite unable to do, or in a great many cases will do incorrectly.

But even were it possible to make automatic spark adjustment perfectly reliable, it would still not answer its purpose of insuring the most advantageous time of ignition. The best *ignition time depends* not only on the speed of the motor, but also on the working pressure and temperature of the mixture. A strongly throttled mixture has to be ignited earlier than a highly compressed one, and a hot mixture later than a cold one. But the centrifugal regulator is not affected by this change in compression and temperature at all, and regulates therefore the time of ignition really in accordance with the alterations in one variable, while there are several others of at least equal importance.

Automatic spark adjustment may be, and is, used when desired without danger of the automobile refusing to work (which is proved by the fact of there being in operation many cars and trucks with no adjustment at all), but its use cannot be considered as an improvement on adjustment by hand.

International Exhibition of Internal Combustion Motors in St. Petersburg (*Die Internationale Ausstellung von Verbrennungsmotoren in St. Petersburg*, N. Bikoff and G. v. Doepp. *Die Gasmotorentechnik*, May 1912. 4 pp., 7 figs. *d*). Description with drawings of four-stroke cycle motors built by the Kolomna and Sormovo Works (Russia) and the Südwerft A.-G., Stockholm, Sweden. The first and last are marine motors, and both reversible. In the case of the Kolomna motors reversibility is secured in the following way: The motor is a four-cylinder, 300-h.p. engine, with a common camshaft to all the cylinders, driven from the main shaft by means of an auxiliary shaft placed in the middle of the motor between the second and third cylinder. Opposite to each cylinder there is placed on the camshaft a double series of cams, for going ahead and astern, controlling the admission and exhaust valves, the naphtha valve and the air valve for starting the motor. The levers of the transmission gear are on the shafts *B* (there are two of them: one for going ahead, and the other astern); on each shaft there is a hand lever *K* which can be placed in any of the positions corresponding to: (1) normal work of the motor; (2) all valves out of operation; (3) starting the motor.

The reversing mechanism works as follows: The position of the lever *K* in Fig. 1 corresponds to normal working of the motor, i. e., going ahead. Should the lever be turned through 45 deg., the naphtha admission valve will be closed by the respective cam; at the same time the naphtha pump will be put out of action, and compressed air admitted to the cylinders *H*. In these cylinders there are pistons which are kept in their upper position by a spring, while the respective piston rods take a position just above the valve spindles, but do not touch them as long as the valves remain closed. As soon, however, as the compressed air presses the pistons down, the valves, with their levers, begin to move sidewise, and the rollers of the levers are lifted up by the cams, thus permitting their displacement, with the help of the levers *G*, along special springs located in the body of the shaft. Then the lever *K* is placed in its third position, in which the lever of the exhaust valve is permitted to come in contact with its corresponding cam on the shaft, while the naphtha pump remains cut out. As a result the compressed air is allowed to flow out of the cylinders *H*, the air and exhaust valves rise, and the rollers of their levers come in contact with the respective cams. When the motor reaches its normal speed of rotation, the lever *K* is placed vertically.

These motors are used mainly for passenger ships on the Wolga, in Eastern Russia, and appear to work satisfactorily.

Cheap Motive Power from Gas Producers with Recuperation of Ammonia (*La force motrice à bas prix par les gazogènes à récupération d'ammoniaque*. F. Charles. *La Houille Blanche*, March 1912. 8 pp., 9 figs. *d*). General, rather popular discussion of the production of power

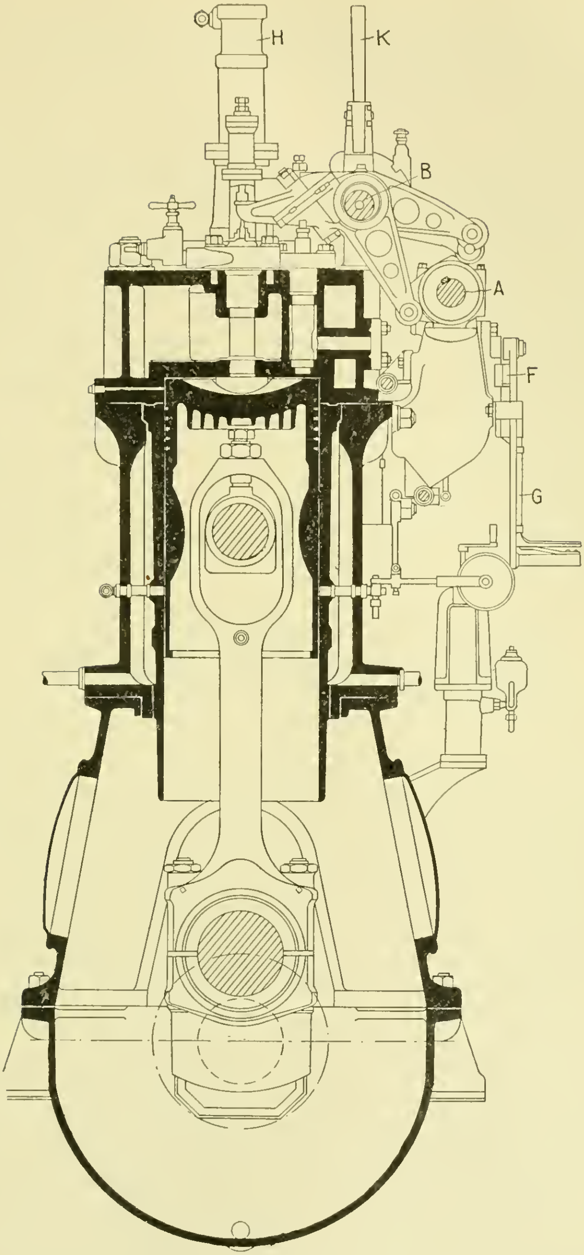


Fig. 1 Four-Cycle Reversible Marine Motor of the Kolomna Works

from blast furnace gases, gas producers, and gases from by-product coke ovens, with several illustrations showing the heat balances of the steam and gas engines and blast furnace. The article may be used for popular lectures and talks to employees.

Machine Shop

THE CEMENTATION OF IRON BY SOLID CARBON (*Sur la cémentation de fer par le charbon solide*, G. Charpy et S. Bonnerot. *Revue de métallurgie*, May 1912. 15 pp., 9 figs. *e*.) Detailed account of the experiments briefly announced before (Cp. *The Journal*, January 1912, p. 120.) The authors have found that at a temperature of 950 deg. cent. (1742 deg. fahr.) no cementation is produced when no gases are present, but there is reason to believe that carbon does diffuse through the iron, as appears to be indicated by structural changes in cast iron and steel heated above the critical points. It is difficult to state, however, what may have been the influence of the occult gases in the metal in such a diffusion. As regards adherence between carbon and iron, the experiments have not been conclusive. It has in no case, however, been anything like the adherence which exists between the graphite and the ferrite in cast iron.

GALVANIZATION OF IRON AND STEEL. PART IV: SHERARDIZATION (*Le Zingage du fer et de l'acier. La Shérardisation*, A. Sang. *Revue de métallurgie*, May 1912. 18 pp., 11 figs. *dA*). Continuation of a series of

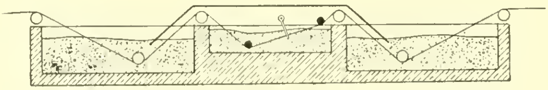


FIG. 2 SANG CONTINUOUS PROCESS OF ELECTRICALLY GALVANIZING STEEL WIRE

articles on various methods of galvanizing iron and steel (beginning in January 1912. Cp. *The Journal*, March 1912, p. 419). The author discusses sherardization mainly on the basis of the work of Dr. C. F. Burgess, of the University of Wisconsin, and Dr. A. S. Cushman, and describes several types of furnaces for this process. He describes also his own continuous process of *sherardizing wires* by heating them *electrically* while they are being drawn through a bath of zinc gray. As shown in Fig. 2, the wire, which does not have to be particularly clean, passes first through a layer of sand, and then below a cover into the zinc gray bath; the part of the wire between the contact points is maintained at a red heat. The wire comes out from the bath in the same manner as it went in, and may be cooled in the air. There are, however, certain essential rules that must be observed in order that the process be successful. There must be some arrangement for making the wire move sidewise, so as always to bring it in contact with fresh particles of zinc gray, and to prevent the latter from forming cavities where the wire would slip without meeting any galvanizing metal. The zinc gray must have attained a certain temperature, but since it is in a receptacle made of refractory material, it is enough to leave the wire stationary in the bath until it reaches the desired temperature, and only then set it in motion. The most difficult part of this installation,

however, is the arrangement of the contacts, because if this is unsatisfactory, only a single point on the wire will be heated, and the wire will come out of the bath red hot, but not sherardized. Besides being galvanized, the wire is also annealed.

New Industrial Burners (*Neure gewerbliche Heizbrenner. Elektrotechnischer Anzeiger*, May 19 and 26, 1912. 3 pp., 18 figs. *d*). Review of German burners for welding and cutting metals. The Jurgens gas blower (Fig. 3, 1 and 2) is a combination of a Bunsen burner and a blowpipe. The blower rotates on the support *f*, and is provided with air and gas ducts *l* and *g*, the air duct *l* connecting with the gas duct when the cock *h* with its angle bore *w* is placed in a suitable position. The gas duct *g* is further divided into two separate ducts k^1 and k^2 leading to the respective plugs of the cock *h*. The gas flows through these ducts into the burner pipe *b* from which either a Bunsen flame or a blowpipe flame may be produced. In the first case the air admission sleeve is placed so that its holes are just over the holes in the burner pipe, giving free admission to the air. The rotation of the sleeve is accompanied, by means of the pin *m*, by a displacement of the slide valve *sch* opening to the gas a passage into the burner pipe through the little holes p^1 and p^2. If the burner is used as a blowpipe, the sleeve *z* is brought to where it covers the holes in the burner pipes, whereby the slide valve *sch* is placed so that the large openings d^1 and d^2 are brought over the ducts k^1 and k^2, and compressed air let on.

Fig. 3, 3, shows the soldering acetylene heated iron of Tr. Baumann in Winterlingen, Germany. The gas pipe *a* is provided with a cock *c* and ends in a nozzle *d* enclosed in the shaft of a spherical burner *e*, this shaft being provided with air admission openings *f*. The nozzle *d* ends in a conical extension *g*, the purpose of which is to produce a narrow flame directed on the iron *i* surrounded by the jacket *h* with its openings *q*. There is also a spring *n* which can be regulated by the screw *o* so that its tip *p* closes more or less the opening of the nozzle *d*, and thus makes the flame strong or weak, as desired. A wire gauze screen is provided at *k*, to prevent backfiring.

In the production of burners using liquid fuel, more economical thermally and less dangerous than acetylene burners, two improvements are credited to Edward Grube in Alt-Rahlstedt, Germany. The liquid fuel must of course be evaporated before it can mix with the air. The first is shown in Fig. 3, 4. A burner with a single superheater coil *A* from which oil vapor is conducted to the distributing member *B*, and is supplied simultaneously to the injectors *E* and nozzle *L*. The oil vapor formed in the superheater coil *A* produces a narrow flame at the exit from the nozzle *L*, as in an ordinary blowpipe, but serves also to feed the welding burner *F*. For this purpose part of the oil vapor is led aside into the injector *E*, and mixes there with the oxygen. To start the burner, the superheater coil *A*, with all valves closed, has to be heated by some outside source of heat. To use the burner for welding purposes, the cock *H* has to be opened, and oxygen admitted ta the injec*t*or *E* through the pipe *D*.

In the second burner of the same concern (Fig. 3, 5), the oil which is led to the burner through the pipe *A* under pressure, enters into the car-

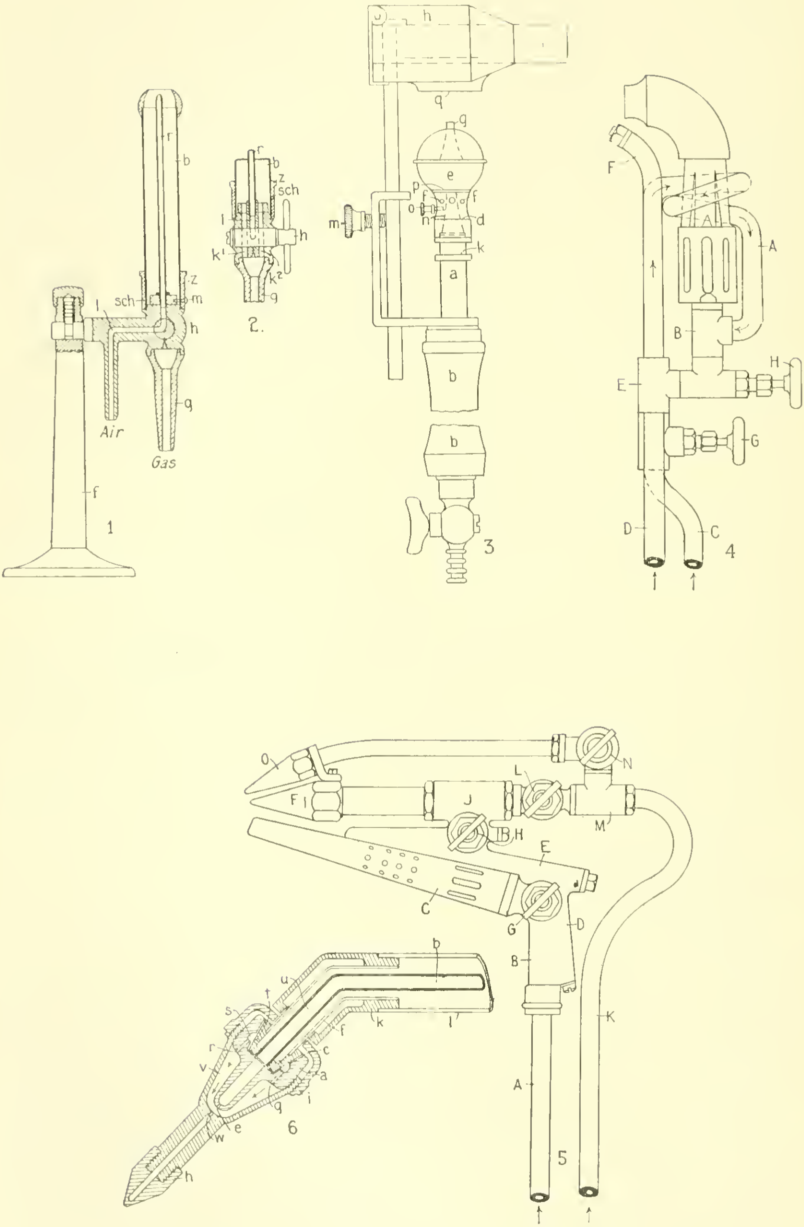
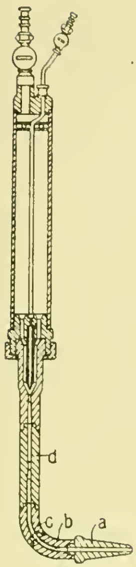


FIG. 3 BURNERS (BLOWPIPES AND TORCHES)



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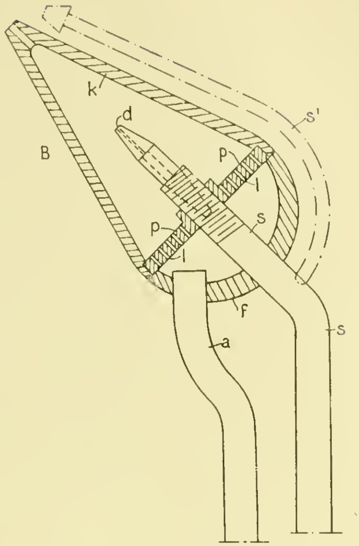

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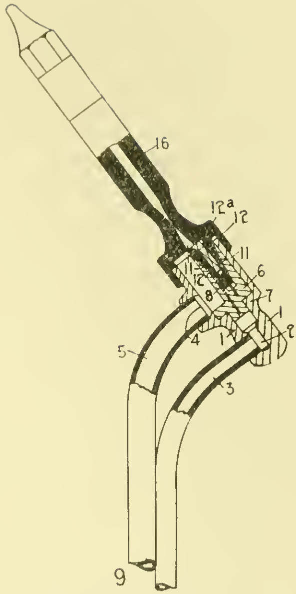

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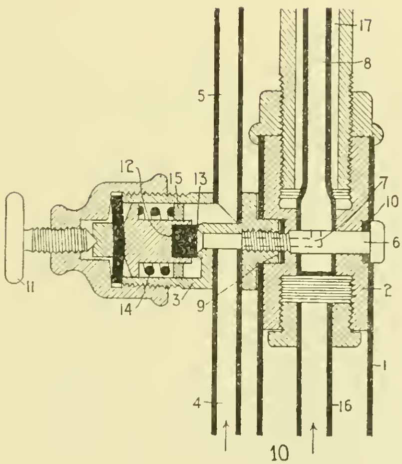

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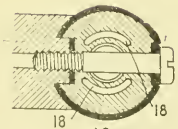
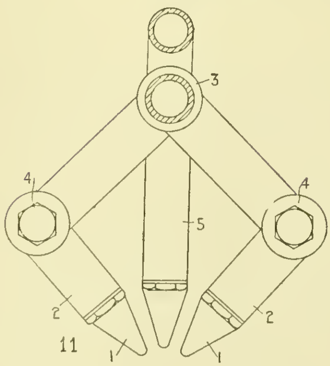


10 a



11

for Welding and Cutting Metals

buretor *B* of the blowpipe *E* as well as through a side duct *D*, into the carburetor *E* of the welding pipe *F*. The valves *G* and *H* regulate the supply of the oil vapor. The carburetor *B* is heated by the heat conducted through the metal from the pipe *C* of the blowpipe, while the carburetor *E* is directly surrounded by the flame of the blowpipe; from *E* the oil vapor passes into the injector *J*, and mixes there with the oxygen coming through the pipe *K*, the flow of the oxygen being regulated by the valve *L*. A branch pipe *M* with cock *N* permits also the regulation of the supply of oxygen flowing under high pressure to the torch for cutting metals *O*.

To obviate the necessity of having several burners of various sizes for different kinds of work, J. Ammon in Schöneberg (near Berlin, Germany) designed a burner (Fig. 3, 6) for welding which may be fitted with different nozzles for different kinds of work. The part *gh* is a nozzle body provided with properly dimensioned ducts for oxygen and fuel gas, with the nozzle and outer tube in permanent connection. The nozzle body *de* is slipped over the hollow conical nipple *c* connected with the oxygen pipe *b* and combustible gas chamber *l*, the two being connected when necessary by the cap screw *i*. The oxygen flows through the pipe *b* into the duct *w*, and out through the burner nozzle *h*. The fuel gas is drawn by the suction, produced by the flow of oxygen, through the duct *t* into the passage *s*, and thence through the duct *r* into the combustion chamber *v*. Another burner, on the same principle, but somewhat different in constructive details, has been designed by W. Widmann in Stuttgart, Germany.

The vapor nozzle of the welding burner of the Rheinische Gesellschaft fur autogene Metallbearbeitung m.b.H. in Cologne, Germany (Fig. 3, 7), consists of several exchangeable parts. The nozzle proper, consisting of three parts, *a*, *b* and *c*, is screwed to the mixing tube *d*, these three parts being provided with similar threads, so that they may be set at any desired angle to the axis of the mixing tube.

The burner of M. Imhoff, of Berlin, Germany (Fig. 3, 8), which may be used both for welding and cutting metals, is constructed so that the oxygen cannot get into the gas pipes. The pear-shaped burner *B* consists of a semi-spherical base *f* and conical vapor nozzle *k*, divided by the plate *p* having a large number of small holes *l* arranged in concentric circles. Acetylene is brought through *a*, oxygen through the pipe *s* passing through the base and plate *p*, and provided with the nozzle *d*. The mixture of oxygen and gas flows out through the nozzle *o*. When the burner is used for cutting metals, an additional stream of oxygen is supplied through the branch piping s^1. The peculiar shape of the burner permits of cutting a number of holes in the plate *p* such as to allow always a sufficient supply of gas to flow through, with no danger of backfiring. The conical extension *k* is said to favor the mixing of the two gases.

Instead of making provisions for exchanging nozzles, the admission of oxygen may be regulated, as is done in the burner of the Apparate-Bau-Anstalt Schmalkalden G.m.b.H., in Schmalkalden, Germany (Fig. 3, 9). The oxygen pipe 3 opens into the chamber 2, while the acetylene pipe 5 is led to the side opening 4. The headpiece 6 is screwed into the casing 1, and is provided with a central duct, with the front part of 6 eccentrically located, and fitted with cone 11 having in its turn longitudinal grooves 12

opening into ducts 12[a]. These ducts are cut in special nozzle-shaped pins connected with cone 11, are of different diameters, and, like the grooves 12, are not limited as to number. Since the path of the oxygen lies through 12[a] enclosed in the cone or pins connected with it, the regulation of the oxygen is not affected by regrinding.

What is claimed to be a new arrangement for distributing the oxygen in burners with a single oxygen piping is embodied in the burner shown in Fig. 3, 10, constructed by J. Knappich in Augsburg, Germany. The oxygen regulating valve 3, with its admission and discharge piping 4 and 5, is fastened by the screw 6 to the body 2 enclosed in a tube protector 1. The screw passes through the duct 8 for the admission of oxygen for the preheater flame, this duct being closed below the screw, and the screw being provided with a bore 7 connecting the oxygen supply pipes 4 and 8. The inside diameter of 8 is so large that there is always a sufficient area for the passage of the gas, independent of the position of the screw 6. The disks 9 and 10 act as packing. By means of the screw 11 the valve 3 can be closed or opened, according as the valve cone 12 is pressed against its seat 13, or lifted from it by the spring 14 having as purchase the disk 15. The fuel gas pipes 16 and 17 are tightly fastened to the body 2, the two

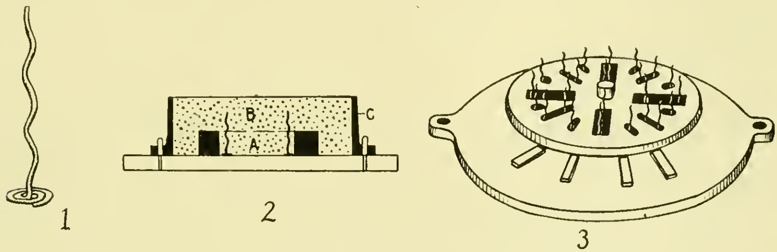


Fig. 4 H. C. Klotz Mold Spiral and Its Application

pipes being connected by the ducts 18. When valve 3 is open, the oxygen brought by pipe 4 flows into 8 as well as into 5. When the valve is closed, the admission of oxygen into the oxidation pipe 5 is stopped, but the gas continues to flow through 7 into the pipe 8.

In the torch for cutting metals of R. Moritz, of Wasquehal, France (Fig. 3, 11), the nozzles of the fuel gas supply pipes are on pin joints, thus permitting the regulation of the heated space opposite the oxidation nozzle. Oxygen is supplied by the pipe 5, and fuel gas by the nozzles 1.

A New Interesting Expedient in the Foundry (*Ein neues, interessantes Hilfsmittel in der Formerei. Giesserei-Zeitung*, May 15, 1912. 2 pp., 6 figs. *d*). The formation of a core in a pattern depends on many things, e.g., quality of the sand, execution and design of the pattern, molding machine used, etc., and does not always succeed, especially when the height of the core is considerably in excess of its diameter. This applies particularly to the case when lifting-type molding machines are used. With turnover-type molding machines the cores can be made easier, because with this type of machine the pattern is lifted out of the mold, and the

sand is not disturbed. But even there it happens often that the sand is pressed so hard into the core hole that when the pattern is lifted, it is torn off, and carried away with the pattern.

To prevent this the firm H. C. Klotz, in Hamburg, Germany, patented the *mold spiral* (*Formspirale*) shown in Fig. 4, 1, and made of hard wire, with the upper part in the form of a spiral, and the base wound like a snake. The coils of the spiral of the vertical part must not be too close to one another, to allow the sand space to get well in. Fig. 4, 2, shows how the spiral is applied in setting the mold. The spirals have to be set as close to the edges of the core as possible; if the core is of angular or otherwise irregular form, the spirals have to be set in the angles, or wherever there is danger of the piece breaking off. Fig. 4, 3, shows how by means of this spiral a face plate can be made without cores. The article states that in one particular foundry there was a saving of 160 cores per day in the manufacture of this one face plate due to the use of the mold spiral.

Thermic and mechanical treatment of metals in the shop: Tempering (*Traitements thermiques et mécaniques des métaux a l'atelier. Revenu*, F. Robin et P. Gartner. *Revue de mécanique*, April 30, 1912. 23 pp., 34 figs. *dt*). A short statement of the theory of tempering, and description of the various furnaces used for this purpose.

Measuring Apparatus

Limits of Use of High Temperature Thermometers (*Die Brauchbarkeitsgrenze der hochgradigen Thermometer*, H. F. Wiebe. *Deutsche Mechaniker-Zeitung*, February 1 and 15, 1912. 10 pp. *e*). Experiments made at the German Government Bureau for physical and technical investigations (Physikalisch-Technische Reichsanstalt) have shown that (*a*) Although the *thermometers* used for these tests, and made of *Jena borosilicate glass* 59^{III}, were submitted by the manufacturer to an aging process of three to four days' duration, these thermometers have nevertheless shown a raising of the ice point up to 7 deg. after a further aging process of about 160 hours at a temperature of 500 deg. cent. It may be accepted, therefore, that it requires an aging of at least ten days at 500 deg. cent. to obtain a constant position of the ice point, with variations not exceeding 0.5 deg. cent. There is, however, no need for a subsequent slow and long cooling, and after a sufficiently long heating at 500 deg. cent. the thermometer may be simply left in the bath to cool down of itself. The reason for the cooling having little effect on the position of the ice point is the slight thermal depression for this kind of glass. (*b*) The limit up to which a high temperature thermometer of Jena borosilicate glass 59^{III} may be used is 510 to 515 deg. cent. The German regulations prohibit the division of such thermometer scales above 510 deg. cent. Hobert C. Dickinson (Heat Treatment of High Temperature Mercurial Thermometers, Bull. Bur. of Standards, 1906, vol. 2, p. 189) finds that Jena borosilicate glass, though the best glass for high temperature thermometers, must not be used for temperatures much above 500 deg. cent.

Compensation-Planimeter Bar with Sharp-Edged Roller (*Kompensations-Planimeterstab mit sharfrandiger Rolle*, Generlich. *Zeits. für Dampf-*

kessel und Maschinenbetrieb, May 3, 1912. 3 pp., 6 figs. *e*). Data of tests of J. Schnockel's *compensation-planimeter bar*, and its comparison with Coradi's planimeter and Amsler's polar planimeter. It was found that when used according to the inventor's specification and instructions, the planimeter bar proved to be correct to within less than 1 per cent, and to be comparatively easy to operate. It is claimed that the absence of joints and gear wheel transmissions make it stronger and more lasting.

Mechanics

HYDRAULIC DRIVE FOR AUTOMOBILES (*Hydraulischer Antrieb für Motor-Wagen*, A. Heller. *Zeits. des Vereines deutscher Ingenieure*, April 13, 1912. 5 pp., 23 figs. *d*). Description of the Lentz hydraulic drive. Cp. *Motorwagen*, April 20, 1912. A translation of the latter article appeared in the *Automobile*, May 30, 1912.

THE NAIL (*Le Clou*. Ch. Fremont. *Bulletin de la Société d'Encouragement pour l'Industrie Nationale*, February to April 1912. *etA*). The third of a series of articles on the *nail:* investigation of properties, construction, forces acting on, etc. A full abstract will be given when the series is finished in the original.

LAW OF SIMILARITY APPLIED TO FRICTION PHENOMENA (*Das Aehnlichkeitsgesetz bei Reibungsvorgängen*, H. Blasius. *Zeits. des Vereines deutscher Ingenieure*, April 20, 1912, 5 pp., 4 figs. *tA*). A theoretical investigation of the limits of applicability of the physical *law of similarity* to *friction* phenomena. A full account of the investigation will shortly appear in the *Mitteilungen über Forschungsarbeiten*, and an abstract will then be given in *The Journal*.

NOTE OF THE CALCULATION OF CRANKS AND SHAFTS (*Note sur le calcul des manivelles et des arbres*, Ch. Dekeyser. *Bulletin technique de l'Association des Ingénieurs sortis de l'Ecole Polytechnique de Bruxelles*, April 1912. 20 pp., 8 figs. *mt*). The author starts from Barré de Saint Venant's formula for maximum deformation under combined stresses:

$$Ei > \frac{3t + \sqrt{(5t)^2 + (10\theta)^2}}{8}$$

where E is the longitudinal modulus of elasticity, i maximum permissible deformation, t and θ normal and tangential stresses. He further derives equations for stresses at various points of the crank which, according to his admission, are only approximately correct and too complicated to be used for practical purposes, but which show that for a given position of the crank, various transversal sections of the crank arm are subjected to different stresses, and that the stresses at different points of each section depend on the position of the arm. He proceeds to give a somewhat complicated graphical method for determining whether in a crank of a given longitudinal section and rectangular cross-section there will be points subjected to stresses exceeding the permissible limit.

SLIDING FRICTION (*Über gleitende Reibung*, Charlotte Jacob. *Annalen der Physik*, No. 6, 1912. 22 pp., 13 figs. *etA*.) Physical investigation of *friction between solids*, with special regard to the *relation between friction*

and speed of motion. The author has found that friction depends to a certain extent on the speed, and up to a certain point rises with the speed, at first rapidly, and then slower and slower until it becomes practically constant. For brass a coefficient of friction 0.103 is thus found.

The relation between *friction and temperature* was found to be as follows: as the temperature rises, the angle of friction at first decreases rapidly, becomes constant at about 150 to 190 deg. cent. (302 to 374 deg. fahr.), and at about 250 deg. cent. (482 deg. fahr., all these figures referring to experiments with glass) begins to rise very rapidly. The minimum of the angle of friction at higher temperatures is as low as one-third of that at room temperature. The remarkable fact observed by the author is that, while the relation between the angle of friction and temperature, from room temperature to that corresponding to the minimum, is reversible, it becomes irreversible for the temperature beyond that of the minimum, i. e., the angle of friction retains its high value even after cooling.

Steam Engineering

Latest Data of Tests of Zoelly Steam Turbines (*Neueste Versuchsresultate an Zoelly-Dampfturbinen. Der praktische Maschinen-Konstrukteur*, May 9, 1912. ½ p. *c.*) Data of tests of several Zoelly turbines of Swiss and German manufacture. The turbines have shown the following steam consumption:

Capacity of Turbine, Kw	R.P.M.	Consumption of Steam, kg/lb.
1,250	3,000	from 5.71/12.6 to 6.71/14.8
5,000	1,500	from 5.42/11.9 to 6.67/14.8
10,000	1,250	from 5.45/11.9 to 6.6/14.7

Water Purification and Elimination of Scale in Boilers (*Über Wasserreinigung und Kesselsteinbekämpfung*, K. Braungard. *Chemiker-Zeitung*, May 9, 1912. 2 pp. *ce.*) Comparison of various methods of *scale elimination*, with special regard to feedwater purification. The author made tests on the efficiency of permutit, and shows that this material may sometimes do a great deal of harm in a boiler. Permutit, like other zeoliths, has the property of giving up only the basic components in exchange for similar components in the alkalis in the water, and in consequence the place of the alkalis is taken by increased amounts of sodium bicarbonate. In boiling water this sodium bicarbonate gives off carbon dioxide according to the formula $2NaHCO_3 = Na_2CO_3 + H_2O + CO_2$, and the soda again breaks up in the boiler, according to the investigations of Blacher and others, into sodium hydrate and carbon dioxide. There is therefore altogether a very large evolution of carbon dioxide which is generally considered a weak and practically harmless gas, but which under conditions present in the boiler attacks the iron just as another dilute acid would do. At the same time the increased alkaline contents of the water attacks the water gage glasses and the packing. The only way to help it would be to let the water off very often, but that involves disadvantages which would destroy all the good that the permutit might otherwise have done.

The author concludes therefore that at any rate dirty water and water containing free carbon dioxide cannot be treated by permutit without being subjected to suitable preliminary processes of purification and deoxidation.

The article contains also a discussion of methods for eliminating iron and manganese from feedwater. (Permutit is a patented product now being introduced in Germany and this country.)

Artificial Draft in Boiler Plants (*Ueber künstlichen Zug bei Dampfkesselanlagen*, H. Hermanns. *Glasers Annalen für Gewerbe und Bauwesen*, May 15, 1912. 3 pp., 4 figs. *d*). General discussion of the advantages of artificial draft in boiler plants, and description of the Schwabach system of induced draft. In this system a fan drives the air through one or more nozzles into a comparatively low smoke stack, and thus produces in the furnace a partial vacuum which may be regulated as required. Tests made by an engineer of the Saxony Association for the Inspection of Boilers with two boilers, one with natural, and the other with induced draft, but absolutely similar in other respects, and handled by the same men, have shown that the cost of producing 1000 kg. (2200 lb.) of steam was in the first case 2.36 marks (say 59 cents), and in the second case (including the cost of driving the fan) 2.26 marks (say 56.7 cents), or a difference in favor of induced draft of 8.5 per cent. The first cost of the Schwabach system of induced draft is said to be much less than that of building a tall smoke stack, besides the fact that in case of transferring the plant from one place to another the smoke stack becomes practically worthless, while the induced draft fan may be moved with very little trouble.

Beluzzo Steam Turbines for Stationary Plants (*Le Turbine a vapore Beluzzo per impianti fissi. L'Industria*, May 12 and 19, 1912. 6 pp., 25 figs. *d*). Description of *Beluzzo stationary steam turbines* (Cp. also *Zeits. des Vereines deutscher Ingenieure*, May 21, 1910). This type has the high, intermediate and low pressure parts quite unlike each other. The high pressure part is in two pressure stages, each with two velocity stages in series, in large units; in small units a single pressure stage and three velocity stages in series. The intermediate pressure part is made of several disks, each with a single blade rim, and each rotating in a separate chamber, the expansion of steam taking place in the distributors of the respective rotors. The low pressure part consists of a drum on which are mounted several blade rings.

Such a turbine is held to possess several important thermal and mechanical advantages. It results, according to the author, in the highest thermal efficiency since, as the pressure and temperature of steam go down, the velocity of efflux from the distributors and the ratio between it and the peripheral speed of the disks also diminish, and this decreases the loss due to friction between the steam and the turbine blades. Further, the arrangement of the high pressure disks in several velocity stages, with minimum expansion in the distributors, permits a rapid decrease in steam pressure between the stages. On the other hand, the drum on the low pressure side makes the rotating part of the turbine more rigid.

The velocity of efflux of the steam from the distributors is 650 to 700 m (say 2100 to 2300 ft.) in the first stage, and 500 m (say 1620 ft.) in the second stage; between 400 and 300 m (1300 to 960 ft.) in the intermediate pressure part, and only about 200 m (650 ft.) in the low pressure part. With such velocities the wear of the blades is practically none.

On coming from the first distributor (Fig. 5), the steam acts on the

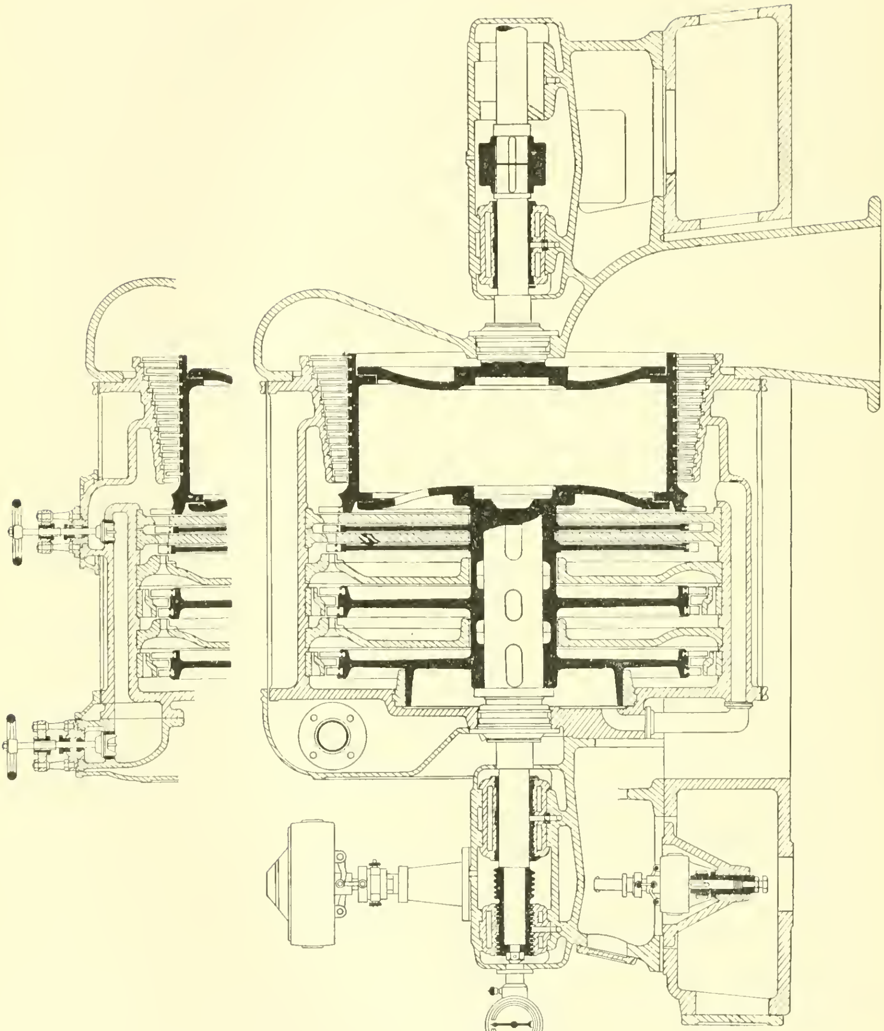


Fig. 5 Belluzzo Steam Turbine for Stationary Plants

blade rim of the first disk, is deflected along the groove in the diaphragm between the two wheels, and enters the distributor of the next wheel. This arrangement prevents the steam from forming eddies when it reaches the distributor of the second wheel, due to the rebound of steam from the first wheel. The first and second wheel have partial admission, and the distributors occupy only parts of the respective peripheries, less than 90 deg. for the first wheel, and a little more than 90 deg. for the second. The intermediate pressure disks have also partial admission, but with a constant angle of about 180 deg. The radial height of blade is thus growing from one disk to another in accordance with the decrease of the velocity of steam and increase of its specific volume. From the last disk of the intermediate pressure section the steam is led to a collector, a sort or receiver between the intermediate and low pressure parts. It has a double duty to perform: in the first instance it distributes uniformly the steam coming from the last disk of the intermediate pressure section,

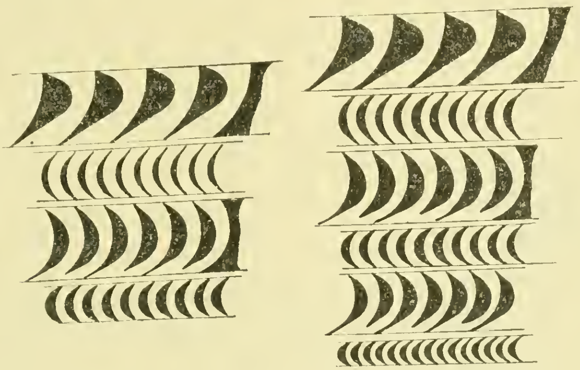


Fig. 6 Distributor and Rotor Construction of the Belluzzo Turbine (Two and Three Velocity Stages in Series)

which has a partial admission, over the drum of the low pressure section having full admission. In the second place it has to maintain the cast iron walls supporting the blades of the distributors of the first wheel at a temperature slightly higher than that of the steam expanding between the disks. Tests made by Professor Belluzzo in 1905 have shown the convenience of such a steam collector. It is of especially great importance for marine turbines in that it prevents the accumulation of water at the bottom of the turbine. Fig. 6 shows the construction of the distributors and rotors. Attention is called to the following: (1) decrease of axial width of the rotor blades from the first disk on to the last; (2) decrease of the peripheral blade pitch; (3) decrease of the angle between the direction of steam, and that of the peripheral velocity; the width of the blades in velocity stages arranged in series is also decreasing. Thereby is gained the great mechanical advantage of having the weight of the blades in various disks, as well as the steam pressure on the blades and the stresses due to centrifugal forces on the various disks, practically uniform.

Evaporation Test of a Double Flue Boiler with Wefer Gas Fired Furnace (*Verdampfungsversuch an einem mit Wefer-Gasfeuerungen ausgerüsteten Zweiflammrohrkessel*, Bütow and Dobbelstein. *Glückauf*, May 18, 1912. 3½ pp., 5 figs. *d*). Description of the *Wefer gas fired furnace*, and data of test of a double flue boiler equipped with it. This furnace is designed to use coke oven gases. Simple nozzles for the admission of the

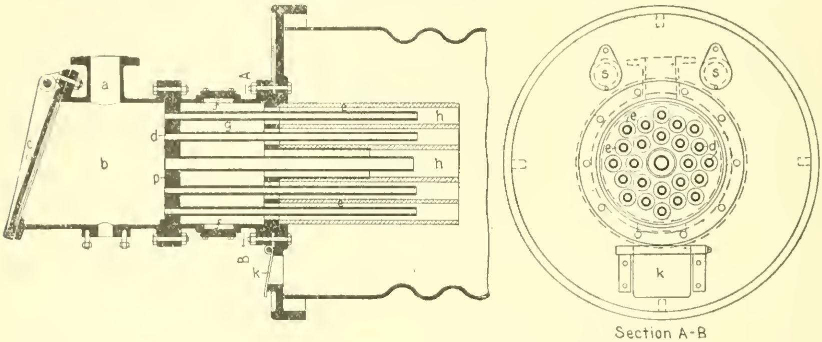


Fig. 7 Wefer Gas Fired Furnace

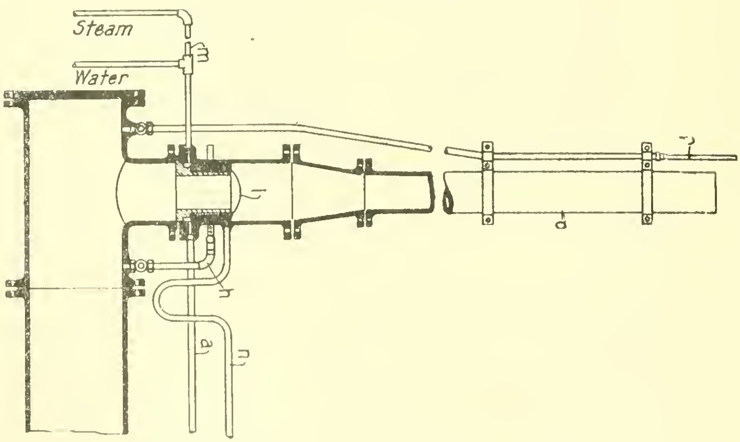


Fig. 8 Wefer Safety Valve for Coke Oven Gas Mains

gas, and admission of air through openings in the flue plate, proved to be unsatisfactory owing to imperfect mixture of gas and air. Terbeck's system proved to be somewhat better, in that it provided for a mixture of the gas and air before ignition, and a supplementary admission of air at the place of ignition, thus insuring a very complete combustion of the gas. This system has, however, a disadvantage in having an explosive mixture formed in the primary nozzles, and that, together with the strongly variable gas pressure in the batteries of coke ovens, leads to frequent small

explosions in the nozzles which not only may injure the furnace, but may, and actually do, cause loss of life and property when starting the fire without due precautions. The Wefer furnace is said to be both efficient and safe. The gas enters through *a* (Fig. 7: to the left is a longitudinal section, to the right cross-section through *A-B*) into chamber *b* provided with a safety lid *c* of such weight that it is not budged by the ordinary gas pressure; should, however, an explosion occur in *b*, the lid is thrown up, and the chamber *b* made wide open. This safety device has been tested several times by artificially produced explosions, and found to be working well. The gases of explosion harmlessly exhaust to the rear of the furnace, the lid falls back in its place, and the furnace continues to work without interruption. From the chamber *b* the gases flow through 25 iron pipes *d*, held by an iron closing plate *p*, to the burners proper *h*. The air enters through the valve *f*, by means of which its admission is regulated, to the air chamber *g*, streams along the gas pipes through the ducts *e*, and mixes with the gas at the ends of the pipes *d*, this mixture being immediately ignited at *h*. The front of the furnace consists of a cylindrical fire resisting piece of graphite into which are led the air ducts *e*. Peep-holes *s* and manholes *k* are provided for inspecting the inside of the furnace, and cleaning the flues.

It was noticed that where there is no gasholder, there is a considerable fluctuation in the gas pressure owing to irregular production of gas by the coke ovens, and that when the gas pressure was above 150 mm. (say 6 in.) of water, there easily occurred small explosions in the furnace. To avoid this a special safety valve (Fig. 8) was installed in the gas main. On the gas pipe is a flanged socket with a cornish double beat valve, with *l* so dimensioned that at a pressure of 150 mm. (6 in.) of water it rises and lets part of the gas out into the outlet pipe *o*, which continues until the pressure falls below the dangerous limit. The gas coming out of *o* is ignited by a small gas flame continually burning at the end of the thin tube *p*. To provide for cases where naphthalin deposits might clog the valve, a hot water supply is installed at *m*, with steam keeping the water at about 80 deg. cent. (176 deg. fahr.), a temperature at which the naphthalin deposits melt; the water is let off through the overflow pipe *n*, placed at the level of the valve head. In order to prevent too rapid cooling of the water in the overflow pipe in winter, the pipe *h*, with holes on the side facing the overflow pipe *n*, is provided: when necessary, a cock is opened, and the gas in *h* ignited, thus making the flow in the overflow pipe *n* certain.

WITTIG ROTARY ENGINES (*Rotierende Machinen System Wittig. Dinglers polytechnisches Journal*, May 4, 1912. 3 pp., 5 figs. *dc*). Description and data of tests of *Wittig rotary engines*. These engines may act either as air or water pumps, or as steam or compressed air engines. Fig. 9 shows the schematic construction of the engine and its mode of operation. At *a*, is an eccentrically placed rotary drum provided with slots in which are placed thin vanes *c*, free to move in and out of the slots, and kept in the position shown by centrifugal force; *k* shows the steam inlet pipe, or air outlet pipe, if the engine is working as a blower. There are several small openings in the casing wall on the left, not shown in the drawing.

TABLE 2 COMPRESSOR FOR COMPRESSION 3 TO 3.5 ATMOSPHERES ABOVE ATMOSPHERIC

Number of Test	1	2	3	4	5	6
R.p.m.	900	900	900	900	900	900
Delivery pressure above atmospheric in atmospheres	4.5	4	3.5	3	2.5	2
Temperature of air at delivery, deg. cent. deg. fahr.	132 269	121 249	112 233	106 222	98 208	92 197
Volume sucked per hr., cbm. cu. ft.	202 7070	215 7525	224 7840	239 8365	256 8960	270 9450
Cooling water per sec., kg./lb.	0.21 0.44	0.21 0.44	0.21 0.44	0.21 0.44	0.21 0.44	0.21 0.44
Temperature of cooling water, deg. cent. deg. fahr.						
(*a*) entering	9 48.2	9	9	9	9	9
(*b*) leaving	23.5 74.3	20.5 68.9	19.5 67.1	18.5 65.3	18 64.4	17.5 63.5
Heat carried away by cooling water per sec., WE/b.t.u.	3.05 12	2.42 9.6	2.2 8.7	2.05 8.1	1.9 7.55	1.78 7.05
Power consumption, h.p.	27.5	23.3	21.7	20.9	19.8	18.9
Heat carried away by the air per sec., WE/b.t.u.	1.78 7.05	1.68 6.7	1.62 6.43	1.63 6.45	1.5 5.97	1.55 6.18

Barometer, 720 mm.
Room temperature, 17 deg. cent. or 62.6 deg. fahr.

TABLE 3 TEST OF STEAM ENGINE

Number of Test	1	2	3	4	5
Pressure of entering steam above atmospheric.	9.45	9.4	9.4	9.35	...
Temperature of steam, deg. cent. fahr.	245 473	230 446	250 482	220 428	200 392
R.p.m.	1490	1490	1490	1490	1500
B.h.p.	10.52	10.52	10.75	10.68	0
Consumption of steam per h.p-hr., kg./lb.	16.6 36.2	17 37.4	16.2 35.6	17.5 38.5	... ...

When the engine is working as a blower or exhauster, the cells formed by the vanes c pass these openings as the size of the cells increases owing to the eccentricity of the drum, and expel the air; from the top of the engine, where the cells reach their maximum, they travel for some time without meeting any openings, and tend to compress the air inside them which they discharge through k when they reach it. If the machine works as a motor, either steam or compressed air, the driving fluid, which will be called steam hereafter, enters from k into the cells opening into it, say into z_1. At the start rotation is produced by the pressure of the steam against the whole area of the foremost blade of cell z_1. As regards the enclosed cells, z_2, the author explains that there is a difference of pressure on the vanes, because the vane foremost in the direction of rotation projects further, and therefore presents a larger area to the steam pressure than the vane further back: the difference in pressures will therefore tend to drive the whole piece in the direction of rotation. The total force

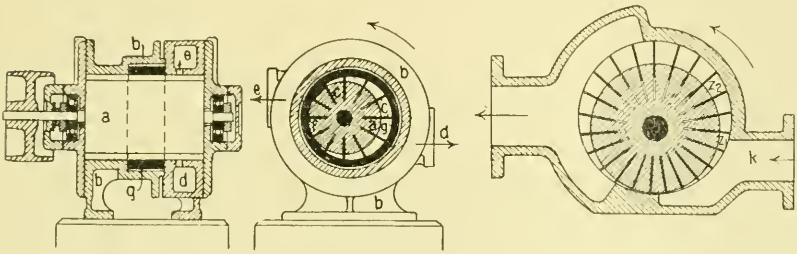


Fig. 9 Wittig Rotary Engine

driving the engine is proportional to the sum of the differential pressures in the cells to the right of the figure, the exhaust openings being on the left, where the cells begin to grow smaller.

The use of a large number of vanes and cells, and the arrangement by which these cells can grow larger and smaller, is said to present the following advantages: (a) There are no valves necessary, the admission and exhaust being effected through uncovered openings, and compression and expansion regulated by the cells changing their size automatically. (b) The difference in size between two contiguous cells being slight, the difference in pressure is also small, and therefore the vanes are subjected to comparatively small stresses, and leaks from one cell to another are small as well. (c) At f, where the drum comes nearest to the casing, and where in an air compressor there would be especial need of packing to divide the suction space from compression, in this machine there is no need of packing at all, because there is always at least one vane c to separate the two chambers. (d) Since the cells are filled or emptied in rapid succession, there is a practically uniform flow of steam or air both into or out of the engine, as well as a uniform turning moment on the shaft.

If, however, the vanes were allowed to press against the casing, there would be a considerable friction between them. To prevent this, there

are provided collars g having nearly the same inside diameter as the casing, and arranged so that they have a certain play both normally to the axis and sidewise. They are carried away by the vanes with them in their rotary movement, and enclose the vanes like hoops around a barrel, the casing proper serving only as a guide to this revolving system. When in contact with the collar, each vane is drawn somewhat sidewise owing to the eccentricity of the slot with respect to the axis of the casing. This eccentricity is, however, of advantage in diminishing the friction losses.

In Tables 2 and 3 are data of tests of a Wittig air compressor and a Wittig 10-h.p. engine receiving steam at 10 atmospheres above atmospheric pressure with exhaust into the atmosphere.

LJUNGSTRÖM REACTION STEAM TURBINE (*La turbine à vapeur à réaction, système Ljungström*, F. D. *Le Génie Civil*, May 18, 1912. 3 pp., 13 figs. and a sheet of drawings). Description of the Ljungström reaction turbine. For a complete description of this turbine see *Engineering*, April 12, 1912.

Thermodynamics

THE JOULE CYCLE (*Sur le cycle de Joule. Comptes Rendus de l'Académie des Sciences*, April 22, 1912. 2 pp. *t*). Some investigators have pointed out that pressure plays a more important part in internal combustion motors than temperature, and that these motors might be better investigated on the basis of the Joule cycle, between the same limits of pressure as the motor, than on that of the Carnot cycle. It becomes therefore of importance to find out under which general conditions this cycle may be substituted for the Carnot cycle.

In the first place, for the given gaseous body, the efficiency of the Joule cycle must be a function of only the extreme pressures.

If now $G(p, S)$ is the thermodynamic potential of a fluid expressed in terms of variables p, S (pressure, entropy), G cannot be any function, but must have the special form

$$G(p, S) = f(p)h(S) + g(p)$$

where $f(p)$ is a positive and increasing function of p, and $h(S)$ is an increasing function of S.

This being the thermodynamic potential, and $A = \frac{1}{E}$ the reciprocal of the mechanical equivalent of heat, the internal heat U, absolute temperature T, and specific volume v will have the following values:

$$U = [f(p) - pf'(p)]h(S) + g(p) - pg'(p), \quad T = f(p)h^1(S)$$

$$v = E[f'(p)h(S) + g'(p)]$$

while the caloric efficiency of the Joule cycle, between the pressures p_o, $p_1 > p_o$

$$p = \frac{f(p_o)}{f(p_1)}$$

These conditions are necessary and sufficient in order that the Joule cycle should have the same properties as the Carnot cycle, when the pressures instead of temperatures are considered. The Joule cycle *may* there-

fore be applied even when the mixture is not considered equivalent to a perfect gas.

Supplementary References

Characteristic curves of Diesel motors (Foreign Review, June 1912, p 958). Complete translation of the article in the *Automobile*, May 16, 1912.

The Aphegraphe (Foreign Review, January 1912, p. 124). Cp. description in the *Engineering Record*, May 25, 1912, p. 570.

The Emperger system of "strapped" or spirally reinforced cast-iron-concrete construction (Foreign Review, April 1912, p. 636, and May 1912, p. 805). Cp. account of same (9 pp., 12 figs.) in *Concrete and Constructional Engineering*, London, June 1912, p. 423.

GAS POWER SECTION

PRELIMINARY REPORT OF LITERATURE COMMITTEE

(XIX)

ARTICLES IN PERIODICALS[1]

COKE OVEN GAS, EXTENSIVE USE OF, C. O. Tupper. *Power*, May 21, 1912. 3½ pp., 5 figs., 2 tables. *cd.*

Composition of gases; gas engine driven electric plants; combined gas engine and steam turbine systems; power equivalent of coke oven gases; by-product recovery plants.

DIESEL ENGINES, CRANKSHAFTS FOR. *Engineering*, May 31, 1912. 2-3 p. *m.*
Discussion of formulæ for crankshaft design.

DIESEL ENGINE, PRESENT STATUS OF THE. *Power*, May 28, 1912. 3 pp., 7 figs., 1 curve. *cdh.*

Early history; commercial types marine engines; Diesel locomotives.

GASTURBINE, DIE, A Stodola, of Zurich. *Zeitschrift des Vereines deutscher Ingenieure*, March 30, 1912. 3¼ pp., 2 tables, 3 curves. *cmp.*

Review and criticism by Professor Stodola of the book of that title by Hans Holzwarth.

INTERNAL COMBUSTION ENGINES, EXHAUST GAS CALORIMETERS FOR, J. S. Nicholson and T. B. Morley. *Engineering*, May 31, 1912. 1 p., 3 figs. *dm.*

Describes apparatus for sampling and analysis of exhaust gases.

MOTOR PASSENGER LAUNCH "VIOLETA." *Engineering*, May 31, 1912. 1½ pp., 6 figs. *d.*

Describes power equipment consisting of two four-cycle petrol paraffin engines of 80 h.p. each.

TREBERT GASOLINE ENGINE, THE. *Power*, June 4, 1912. 1½ pp., 2 figs. *d.*
Describes a six-cylinder four-stroke cycle engine for aeroplanes.

WASSERGAS, EINRICHTUNG UND BETRIEB VON. HALBWASSERGAS UND SAUGGASANLAGEN. *Kraft*, March 21, 1912. 1⅛ pp. *p.*

Certain basic principles for the arrangement and operation of water-gas, semiwater (Dowson) gas and suction gas plants.

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[1] Opinions expressed are those of the reviewer, not of the Society. Articles are classified as *c* comparative; *d* descriptive; *e* experimental; *h* historical; *m* mathematical; *p* practical. A rating is occasionally given by the reviewer, as *A*, *B*, *C*. The first installment was given in The Journal for May 1910.

STUDENT BRANCHES

ARMOUR INSTITUTE OF TECHNOLOGY

The last regular meeting of the Armour Student Branch took the form of a banquet at the Boston Oyster House on May 15, A. J. Beerbaum being toastmaster. Following are the speakers of the evening: Professor Gebhardt, Mem. Am.Soc.M.E., spoke of the importance of keeping in touch with one's Alma Mater; Professor Frith, Mem.Am.Soc.M.E., The Future of the Gas and Gasolene Engines; Professor Coffeen, The Value of a College Course in the Business World; Professor Perry, who was a member of the first graduating class, told of the early days at Armour. E. R. Burley, the newly elected chairman, gave his plans for making the coming year a successful one.

LEHIGH UNIVERSITY

The last meeting of the year of the Lehigh University Student Branch was held May 16, when Calvin W. Rice, Secretary of the Society, told the students of the need of branch societies to encourage scientific discussion, and also what results are to be derived by affiliation with The American Society of Mechanical Engineers.

CORNELL UNIVERSITY

At a meeting of the Sibley College Student Branch, held May 4, Mr. Johnson, president of the Baldwin Locomotive Works, addressed the students on the fallacies of some present-day notions of success.

MASSACHUSETTS INSTITUTE OF TECHNOLOGY

On May 13 the Mechanical Engineering Society was addressed by Charles T. Main, Mem.Am.Soc.M.E., on the Commercial Efficiency and Special Uses of Power Plants. Many points were brought up in the discussion which were of special interest to those students taking the mill engineering option at the institute.

PURDUE UNIVERSITY

At a meeting of the Purdue University Student Branch on April 17, L. W. Wallace of the School of Mechanical Engineering, read a paper on the Efficiency in Railway Management. On May 15, C. B. Veal, Mem.Am.Soc.M.E., spoke on Aerial Engineering.

UNIVERSITY OF CINCINNATI

At a meeting of the University of Cincinnati Student Branch, held May 17, Mr. Pollard, mechanical engineer of the Cincinnati Water Works, delivered an illustrated lecture on the History and Development of the Cincinnati Water Works System.

NECROLOGY

HENRY S. ROBINSON

Henry S. Robinson was born at Meredith, N. H., January 22, 1831, and died April 4, 1912. After completing what was at that time considered to be a good academic education, he took up the active duties of life in 1847 as assistant engineer of the Hamilton Manufacturing Company at Lowell, Mass., and later became consulting engineer for the same company. In 1849 he went to the York Mills at Saco, Maine, as chief engineer, where he remained six years. From 1855 until 1861 he and his brother, James R. Robinson, were in business at Clinton, Mass., as consulting steam engineers. During the Civil War he served for a short time as assistant engineer in the Navy and later in the Army as lieutenant in the 36th Regiment of Massachusetts. From 1865 until 1873 he had charge of the steam plant at the Pacific Mills, Lawrence, Mass., and in 1873 engaged in the business of boiler manufacturing at Boston, at the same time acting as consulting engineer for many of his former clients. In 1892 he retired from active business and allied himself with The Atlantic Works, Boston, of which company he was vice-president from 1892 until 1898, and president from 1898 until his death.

From an engineering standpoint, Mr. Robinson's life was particularly noteworthy for the practical results which he achieved in improving methods of steam boiler construction and operation, and in convincing his clients and customers of the desirability on economic grounds, and duty for humanitarian reasons, to design, construct and operate steam boilers with a careful and intelligent regard for the natural laws affecting them. Before his death he had the satisfaction of knowing that methods which he had advocated and practised many years before were being quite generally adopted by engineers and boiler manufacturers, and in some particulars were being required by legislative regulations.

JOHN T. HAWKINS

John T. Hawkins was born in Abingdon, England, December 22,

1828. When eight years of age he came to America and attended the public schools of New York City. His first employment was with Hoe & Company, printers, with whom he remained until July 1861, when he joined the Navy as third assistant engineer. For efficiency of service he was promoted to a chief engineer's berth, in which capacity he served until the close of the war. He was present at the attacks on Forts Jackson and St. Phillips, the capture of New Orleans and many less important engagements. The following four years he taught engineering chemistry and physics at the United States Naval Academy at Annapolis, and then together with George R. Holt, another naval officer, resigned from the service and engaged in spool making at Salisbury, Vt. His next connection was with the Campbell Printing Press and Manufacturing Company, Taunton, Mass., of which he became president and was in entire charge of the mechanical part of the business. During this period he made many improvements on printing machinery and had taken out over fifty patents on his inventions. In 1897 he became consulting engineer for the Crown Cork & Seal Company, Baltimore, Md., and three years later retired from active business. He died April 29, 1912.

REPORT OF MEETING

BOSTON MEETING, MAY 26

The American Institute of Electrical Engineers held a meeting at the Harvard Union, Harvard College, Cambridge, Mass., on May 26, at which the American Society of Civil Engineers and the Society coöperated. Following the inspection of the engineering laboratories in Pierce Hall, supper was served in the Union, and Professor Hollis, Mem.Am.Soc.M.E., opened a discussion on the field for the low-pressure turbine. He spoke at length of some installations which had come especially under his observation, and gave his views as to the field for such a machine. Others taking part in the discussion were: S. A. Moss, Mem.Am. Soc.M.E.; G. H. Diman, Mem.Am.Soc.M.E.; F. H. Hayes, Mem.Am.Soc.M.E.; W. G. Starkweather, Mem.Am.Soc.M.E.; C. A. Read, Mem.Am.Soc.M.E.; A. E. Kennelly, N. J. Neall, F. N. Gunby and others.

EMPLOYMENT BULLETIN

The Society considers it a special obligation and pleasant duty to be the medium of securing better positions for its members. The Secretary gives this his personal attention and is most anxious to receive requests both for positions and for men available. Notices are not repeated except upon special request. Copy for the Bulletin must be in hand before the 12th of the month. The list of men available is made up of members of the Society, and these are on file in the Society office, together with names of other good men not members of the Society, who are capable of filling responsible positions. Information will be sent upon application.

POSITIONS AVAILABLE

0173 Instructor in steel works engineering, design of mill machinery and furnaces, wanted by engineering school in western Pennsylvania. Technical graduate with at least six years of practical experience preferred. Excellent opportunity for right man.

0174 Consulting factory management expert, desires to negotiate working agreement or co-partnership with gentleman equally qualified in the organization and management of sales departments.

0175 Company manufacturing hoisting and conveying machinery located in the Middle West, desires young man with knowledge of shop management and wage systems, also experience in machine shop. Give full details of experience, positions held, references and salary accepted to start. Permanent position in good locality assured the right man. Apply through Am.Soc.M.E.

0176 Company manufacturing electric cranes, wants experienced designing engineer, one high-class structural draftsman and one general detail draftsman. Applicants must give full information as to former positions, experience and salary expected. Apply through Am.Soc.M.E.

0177 Wanted for plant in vicinity of Philadelphia, young or middle-aged man to carry out under direction, the details of a cost and follow-up system, as well as arrangement of new machinery. Salary dependent largely on incumbent and at rate from $1500 to $2500.

0178 Young designing engineer wanted on high-speed automatic steam engine design; experience in four-valve engines. Salary $1000 to $1200.

0179 Assistant superintendent leading to position of superintendent. One familiar with gas engine and gas tractors, with at least five years' experience and from 35 to 40 years of age; familiar with modern shop practice and scientific management, capable of organizing and good executive ability. Salary to start $200 a month.

0180 Competent mechanic to take charge of new shop. Must be thoroughly

experienced in quantity production in sheet metal, including press work, drawing and spinning, and experience in handling men. Prefer man experienced in manufacture of light steel sheet metal boxes, stamping and making seamless cans; enameling sheet steel. State age, references and salary .expected. Location near New York. Apply through Am.Soc.M.E.

0181 Active man in sales engineering department, to handle feedwater domestic service, heating system heaters and expansion joints, in and about vicinity of New York City. Technical graduate with engineering experience along power plant line, having acquaintance with architects and engineers, and general engineering trade preferred. Apply through Am.Soc.M.E.

MEN AVAILABLE

446 Junior, technical graduate, age 29, married; experienced in motor car design and manufacture, desires permanent connection with concern producing pleasure or industrial motor cars. Now holds position of chief engineer with established motor car company.

447 Chief engineer or superintendent of large power plant or number of smaller ones. Experienced in railway and lighting, also construction work.

448 Position as chief draftsman, sales engineer or assistant manager, wanted by engineer with broad experience in design of boilers and general steel plate construction. Location in or near Baltimore, Philadelphia or New York preferred.

449 Works manager, competent to organize all departments of manufacturing plant along modern lines, long experience on light manufacturing, involving interchangeable parts.

450 Junior, six years' experience in power plant and fuel engineering work, desires position with engineering or contracting firm in design or construction.

451 Member, electrical and mechanical engineer having office in high-class office building and advantageous business connections, desires to represent manufacturer as agent in Chicago in connection with engineering practice.

452 Five-thousand dollar man, is desirous of obtaining a position as chief engineer, consulting engineer or shop manager. Wide experience in steam and hydraulic engineering. Unsurpassed references. Location in or near New York City.

453 Junior, thoroughly acquainted with steam machinery, and selling conditions; exceptional experience in agency and territorial agreements, will consider opening as sales manager or assistant at salary and commission. Write care of Am.Soc.M.E.

454 Competent executive, 36 years of age, eight years' experience as manager and superintendent of industrial plants, desires position; broad experience in engineering lines, machine shop practice, organizing and systematizing; yearly remuneration during past five years averaged $5000 per year.

455 Member with extensive experience in large machine and tool manufacturing plants from finest and most accurate classes of precision work to the heaviest; thorough practical knowledge of tools, machinery, equipment, modern shop practice organization and management, seeks connection as superintendent, master mechanic or factory manager. Salary not less than $3000, and can earn more.

456 Mechanical engineer, as plant engineer or engineering general assistant. Maintenance and construction buildings, power and miscellaneous equipment, safety fire protection and transportation systems, experimental, testing and inspection departments; railroad government and factory experience.

457 Mechanical graduate, age 34, wishes to change; as general testing and inspection engineer, mechanical, electrical, construction, materials, for responsible service.

458 Junior, technical graduate, with nine years' practical experience covering building construction and superintendence, machine and structural design, plant installation and improvements, the design of concrete handling plants and appliances, desires position as mechanical engineer or assistant to consulting engineer. Location New York or vicinity. Salary $2000.

459 Member desires change of location, with nine years' teaching experience in technical subjects, and four years' practical experience, desires position in the East as designing engineer where some inventive ability is required. Can design and superintend the building of automatic machines for turning out special work in quantity. Would consider teaching position in drawing, descriptive geometry or kinematics of machines.

460 Graduate mechanical engineer, with extensive experience in manufacturing interchangeable machinery. Specially good experience in the design of machinery, jigs, and fixtures for the production of duplicate parts, also in testing, handling and use of glues and adhesives. Now mechanical engineer with large wood and iron working factory; wishes position as superintendent.

461 Junior, technical graduate, 31 years of age, married, with six years' experience in general machine shop work, six years' in power house design and construction and a thorough knowledge of modern tools, equipment, shop methods and management, desires position as superintendent with growing concern. At present, chief draftsman for power house engineers and contractors.

462 Member, mechanical engineer, power house design, heating, ventilating, etc. Best of references, open for engagement.

ACCESSIONS TO THE LIBRARY

With Comments by the Librarian

This list includes only accessions to the library of this Society. Lists of accessions to the libraries of the A. I. E. E. and A. I. M. E. can be secured on request from Calvin W. Rice, Secretary Am. Soc. M. E.

Die Abwärmeverwertung im Kraftmaschinenbetrieb, Ludwig Schneider. ed. 2. *Berlin, 1912.*

American Practice in the Rating of Internal Combustion Engines, T. C. Ulbricht. *1912.* Gift of the author.

The American Society of Mechanical Engineers. Yearbook, 1912. *New York, 1912.*

American Society of Swedish Engineers. List of Members, May 1, 1912. *Brooklyn, 1912.*

American Telephone & Telegraph Company. Annual Report of the Directors to the Stockholders, 1911. *New York, 1912.* Gift of the company.

Bau und Betrieb von Kältemaschinenanlagen, C. Heinel. *München,* 1906.

A Book of Portraits. Containing photographs of 564 of the 1500 contributors to the Encyclopaedia Britannica. *New York.* Gift of Encyclopaedia Britannica Company.

Central Station Heating, B. T. Gifford. *New York, 1912.*

Cold. Vols. 1-2, vol. 3, nos. 1-7. *Calcium, 1909-1912.* Gift of Madison Cooper Co.

Concrete Costs, F. W. Taylor and S. E. Thompson. *New York, J. Wiley & Sons, 1912.*

Tables and recommendations for estimating the time and cost of labor operations in concrete construction and for economical methods of management. The information given in the tables as to how long workmen should take to do all kinds of tasks, has been obtained by watching one man after another while he was doing a day's work, and noting with a stop-watch the time taken in doing each small element of the trade.

The immense amount of labor involved in getting together the data for this work is evident from the statement in Mr. Taylor's introduction, where it is stated that Mr. Thompson and his assistants have spent seventeen years in a minute, painstaking study of the building trades, and this is the first book resulting from this work, which deals with the time and cost problem. Works are promised on earth work; bricklaying; lathing; plastering; carpentry; slating, and many of the smaller trades. It is certain that this work will be looked on in the future as foreshadowing a new era for the workman, as well as for the contracting employer.

Mr. Taylor says: "It is our firm conviction that the introduction of the principles of scientific management into this field will produce the same beneficent results that have been secured elsewhere: that high wages earned by the workman and a low labor cost secured by the employer will convince both sides that it is for the interest of each to have the welfare of the other at heart; that friendly co-opera-

tion is better than suspicious watchfulness or open antagonism; that peace is better than war And if this book helps in bringing about this result it will have fulfilled its most important object."

Congreso Cientifico (1o Pan Americano) Ciencias Naturales, Antropologicas y Etnologicas. Vol. 2. *Santiago de Chile, 1911.* Gift of the congress.

Congreso Cientifico (1o Pan Americano) Agronomia y Zootecnia. Vol. 15. *Santiago de Chile, 1911.* Gift of the congress.

Elementary Mechanical Refrigeration. A Simple and Non-technical Treatise, F. E. Matthews. *New York, 1912.*

Encyclopaedia Britannica. ed. 11, vols. 1-29. *Cambridge, 1910.*

Engineering Society of Wisconsin. Proceedings of 3d Annual Convention, 1911. *Madison, 1911.* Gift of the society.

Das Flugzug für die Kriegsmarine und den Wassersport, Theorie und Praxis im Bau der Wasserflugzeuge (und Gleitboote), K. F. M. Rösner. *Berlin, 1912.*

Forscherarbeiten auf dem Gebiete des Eisenbetons. pt. 18. *Berlin, 1912.*

Ueber Grundlagen für den Bauvonkraft-wagen, Dr. Hofmann. *Berlin, 1912.*

Hjorth, Soren. Inventor of the Dynamo-electric Principle, Sigurd Smith. *Kobenhavn, 1912.*

International Congress of Refrigeration (2d), Vienna. English edition. 1910. *Vienna, 1911.*

Lehrbuch der Thermochemie und Thermodynamik, Otto Sackur. *Berlin, 1912.*

Der Luftwiderstand und der Flug, G. Eiffel. *Berlin, 1912.*

Mitteilungen über Versuche ausgeführt vom Eisenbeton-Ausschuss des österreichischen Ingenieur und Architekten Vereins. Vol. 1, 2. *Leipzig, 1912.*

Motorwagen und Fahrzeugmaschinen für flüssigen Brennstoff, A. Heller. *Berlin, 1912.*

National Association of Railway Commissioners. Proceedings of 23d Annual Convention. *Chicago, 1912.*

Eine neue Verwendung des Gusseisens bei Säulen und Bogenbrücken, F. von Emperger. *Wilhelm Ernst & Sohn. Berlin, 1911.*

Attention has been called to Dr. Emperger's "strapped" concrete in the Foreign Review of The Journal (April, 1912, p. 636). This system consists in covering a cast-iron member by a concrete jacket strapped all around by a wire helix. The cast-iron member may be either a solid column, or a hollow tube. The present pamphlet, written by the inventor of this system, who is also editor of *Beton und Eisen*, contains numerous data of tests of strapped concrete and rules for the design of columns, as well as the principles of design of arched bridge members in strapped concrete-iron tubes. The advantages claimed for the Emperger system of construction are that it adds to the toughness of the cast iron, and makes the concrete construction more reliable.

New Jersey Public Utility Board. Annual Report, 2d, 1911. *Trenton, 1913.* Gift of the board.

New York City Board of Water Supply. Contract 132. Borings on and near the site of the proposed Silver Lake reservoir, 1912. Gift of the board.

Phénomènes Thermique de l'Atmosphère, Emile Schwoerer. *Paris.* Gift of the author.

Polytechnic Engineer. Vol. 12, 1912. *Brooklyn, 1912.* Gift of Polytechnic Institute of Brooklyn.

Press Reference Library (Southwest Edition). Notables of the Southwest. *Los Angeles, 1912.* Gift of Los Angeles Examiner.

Rapport sur un Mémoire de M. Emile Schwoerer Intitule "Les Phénomènes Thermiques de L'Atmosphère," M. E. Bouty. *Paris, 1910.* Gift of E. Schwoerer.

Refrigeration, Cold Storage and Ice Making, A. J. Wallis-Tayler. ed. 3. *New York, 1912.*

Reinforced Concrete Buildings, E. L. Ransome and Alexis Saurbrey. *New York, 1912.*

Robinson, Stillman Williams. A Memorial. *Columbus, Ohio State University, 1912.* Gift of Ohio State University.

Rotor ein deutscher Rotations-Flugmotor, F. Hansen. *Berlin, 1912.*

Sanitary Problems of the Board of Water Supply, A. J. Provost, Jr. (Reprint from Municipal Engineers of the City of New York, 1911.) Gift of the author.

Selbstkostenberechnung gemischter Werke der Grosseisen-industrie, H. Wagner. *Berlin, 1912.*

Speed and Power of Ships, D. W. Taylor. Vols. 1-2. *New York, 1911.*

Sperry Gyro-Compass and Navigation Equipment. *New York, 1912.* Gift of Sperry Gyroscope Company.

Die Spezialstähle, G. Mars. *Stuttgart, 1912.*

Swedish Engineers' Society of Chicago. Year Book 1911, 1912. *Chicago, 1911-1912.* Gift of society.

Das Trocknen und die Trockner, Otto Marr. *München, 1910.*

Twelve Principles of Efficiency, Harrington Emerson. *New York, 1912.*

Valuation of Public Utility Properties, Henry Floy. *New York, McGraw-Hill Book Co., 1912.*

The author has been engaged for several years in valuing property aggregating hundreds of millions of dollars. A similar work by Horatio A. Foster was issued at about the same time. The valuation of public utilities has become an important part of the plans for the regulation of public service corporations, and the appearance of these volumes is especially timely. The discussion of the vexed question of depreciation is particularly full.

Walworth-English-Fleet Company. "1912 U. S. Standard" schedule of standard weight and extra heavy flanged fittings and flanges. *Boston, 1912.* Gift of the company.

Zeitschriftenschau der gesamten Eisenbetonliteratur 1911, R. Hoffmann and A. Fitzinger. *Berlin, 1912.*

Die Zwischendampfverwertung in Entwicklung, Theorie und Wirtschaftlichkeit, Ernst Reutlinger.

Gift of Mr. E. B. Renwick

The Society wishes to thank Mr. E. B. Renwick for a large number of interesting books and pamphlets which he has placed at the disposal of the United Engineering Society Library.

UNITED ENGINEERING SOCIETY

INVESTIGATION OF THE ECONOMY OF A SIMPLE ENGINE OPERATING WITH STEAM LESS THAN THAT OF ATMOSPHERIC PRESSURE, R. C. Carpenter. Gift of the author.

KENTUCKY AGRICULTURAL EXPERIMENT STATION OF THE STATE UNIVERSITY. Bull. No. 154. Blowing Stumps with Dynamite. *Lexington, 1911.* Gift of the agricultural experiment station.

MANUALS OF SAFETY, YARD PRACTICE, WALKS AND RAILINGS, Chas. Kirchhoff and W. H. Tolman. *New York, 1912.* Gift of American Museum of Safety.

MOODY'S MANUAL OF RAILROADS AND CORPORATION SECURITIES. ed. 13, 1912. *New York, 1912.*

NATIONAL WATERWAYS COMMISSION. Final Report. *Washington, 1912.* Gift of the Commission.

RULES OF PRACTICE IN THE UNITED STATES PATENT OFFICE. Revised July 17, 1907. *Washington, 1912.*

TITANIC DISASTER. Report of the Committee on Commerce United States Senate. *Washington, 1912.* Gift of Senator W. A. Smith.

TREATISE ON HYDRAULICS, Mansfield Merriman. ed. 9. Revised and rewritten with the assistance of Thaddeus Merriman. *New York, J. Wiley & Sons, 1912.*

This well-known work appears in a new dress, with much new matter. Nearly ten years have elapsed since the last complete revision, and now the book contains the results of the work of the last decade. Of the several editions of this work, 37,000 copies have been printed, the first edition being issued in 1889. The great increase in the development of the water power plants in the country emphasizes the importance of a thorough revision of this standard work.

SWITZERLAND—PATENTE JAHRES-KATALOG XXIII JAHRGANG, 1911. Brevets. Catalogue Annuel XXIIIme Année, 1911. *Brugg, 1912.*

WHO'S WHO IN AMERICA. 1912-1913, vol. 7. *Chicago, 1912.*

EXCHANGES

AMERICAN GAS INSTITUTE. Proceedings. 1911, pts. 1-2. *New York, 1912.*

AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS. Transactions. vol. 16. *New York, 1910.*

INSTITUTION OF MECHANICAL ENGINEERS. List of Members, March 1, 1912. *London, 1912.*

WESTERN SOCIETY OF ENGINEERS. Year Book, 1912. *Chicago, 1912.*

TRADE CATALOGUES

ALBERGER PUMP CO., *New York.* Alberger centrifugal pumps and steam turbines, 71 pp.

AMERICAN BLOWER CO., *Detroit, Mich.* Bull. no. 330, "Ventura" disc ventilating fans, 19 pp.

S. F. BOWSER & CO., *Fort Wayne, Ind.* Bowser oil filtration and circulating systems, 28 pp.

BRISTOL CO., *Waterbury, Conn.* Bristol's recording gages for pressure and vacuum, 63 pp.

Hess-Bright Mfg. Co., *Philadelphia, Pa.* Ball bearings in wood-working machinery, 31 pp.

Hewitt Motor Co., *New York.* Hewitt trucks, 42 pp.

Ideal Case Hardening Compound Co., *New York.* Case hardening, pack hardening, annealing with ideal compound, 20 pp.

M. W. Kellogg Co., *New York.* Fire welding of pipe flanges and nozzles, 12 pp.

J. E. Lonergan Co., *Philadelphia, Pa.* Boiler steam and gas engine fittings, 63 pp.

The Lunkenheimer Co., *Cincinnati, O.* Brass and iron valves, lubricators, oil pumps, motor accessions and machine supplies, 654 pp.

W. M. Matthews & Bros., *St. Louis, Mo.* Supplies for telephone, light, railway and general electric use, 152 pp.

Mid-Western Car Supply Co., *Chicago, Ill.* Anderson friction draft gear, 12 pp.

Morse, Williams & Co., *Philadelphia, Pa.* Hudley worm gears and spirals, 110 pp.

Siemens & Halske, *Berlin.* Frahm vibration tachometer, 8 pp.

Thomson Electric Welding Co., *Lynn, Mass.* Electric welding machines, 72 pp.

Wellington Machine Co., *Wellington, O.* Brick machinery, 52 pp.

Westinghouse Electric & Mfg. Co., *East Pittsburgh, Pa.* Circular No. 109A, Westinghouse turbo-alternators, 36 pp.

Weston Electrical Instrument Co., *Newark, N. J.* Miniature precision direct-current instruments, 31 pp.

Henry R. Worthington, *New York.* Outside packed plunger pattern pumps, 40 pp.

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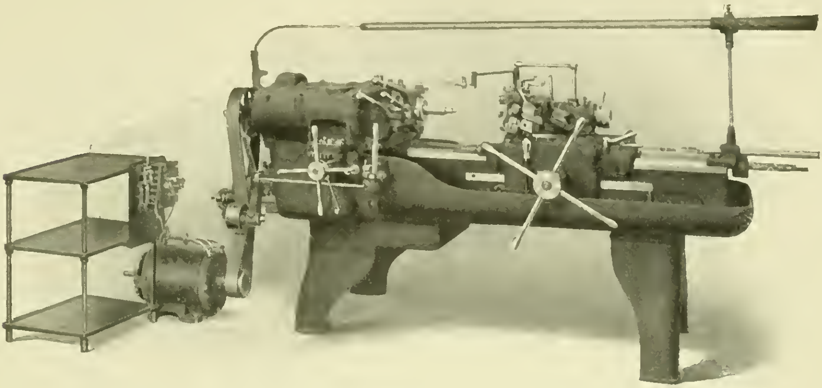

2 x 24-inch Flat Turret Lathe with Cross Sliding Head, Equipped for Bar Work (Motor Drive)

The Hartness Flat Turret Lathe with cross sliding head is made in two sizes, and may be furnished with an equipment of tools for either bar work or chuck work, or a double equipment for both bar and chuck work.

The smaller machine, shown above and on preceding page, is called the 2 x 24-inch, and when equipped with the automatic die outfit of tools it turns nearly every conceivable shape under dimension of 2¼ inches diameter and 24 inches of length. The hole through the spindle is now made 2⅜ inches. For various details of working range and outfit for bar work, see pages 14 to 44. Itemized outfit, pages 86 and 87.

This machine, equipped for chuck work, is described on pages 45 to 85. See also pages 22 to 26.

The machine may be ordered with either the chucking or bar outfit, and supplied later with the other outfit, if for any reason the machine should be changed from bar to chuck work, or *vice versa*. Since the chucking outfit is comparatively inexpensive, it is frequently ordered with the bar outfit of one or more machines of a lot, so that at least one machine may be used on short notice for chuck work.

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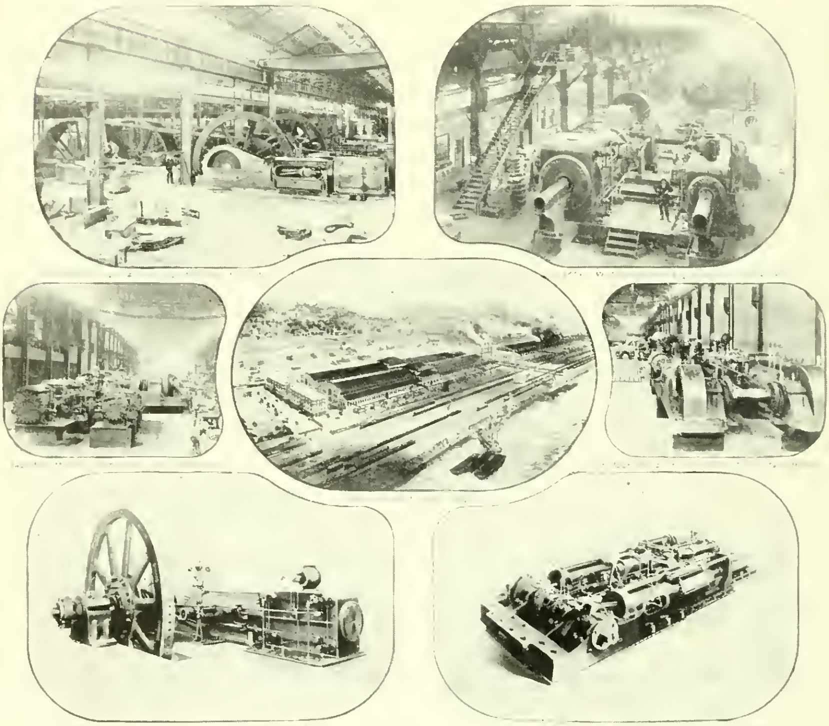

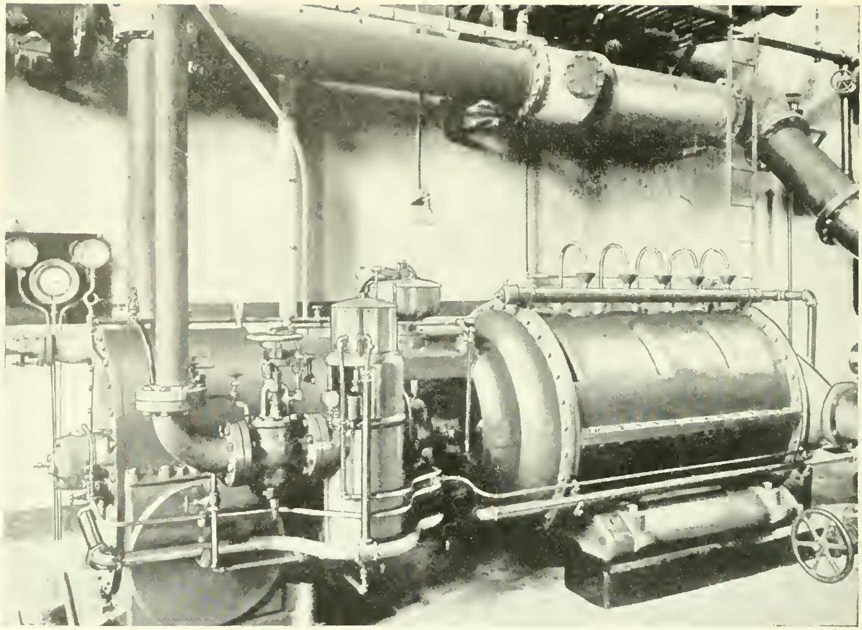

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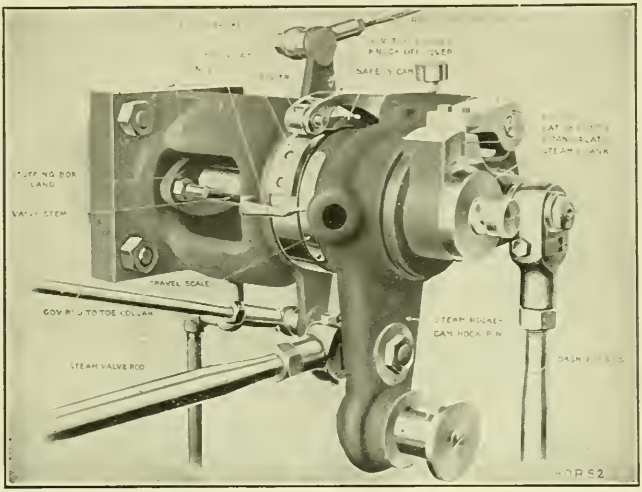

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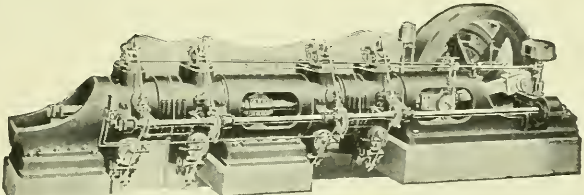

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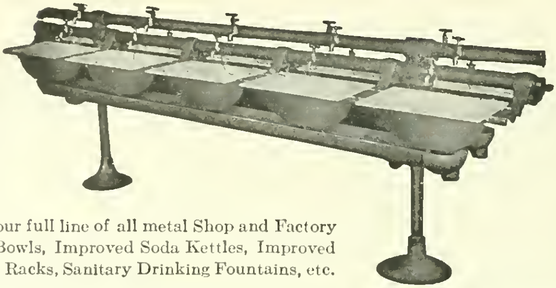

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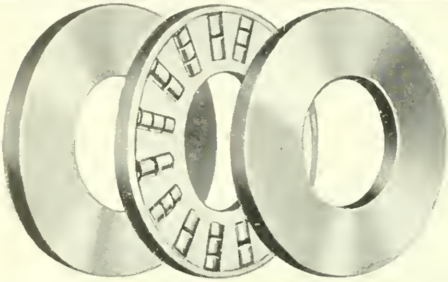

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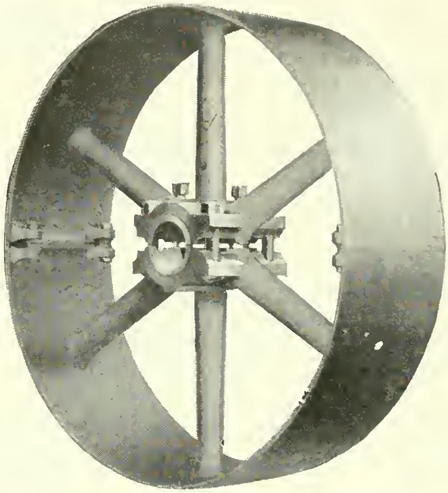

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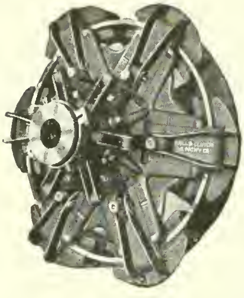

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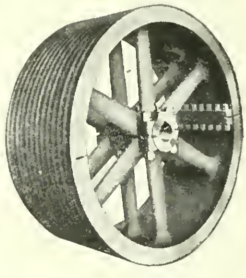

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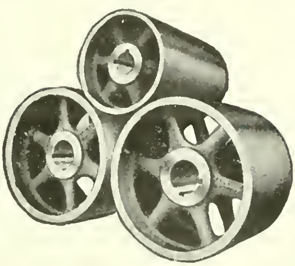

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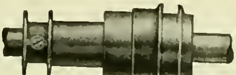
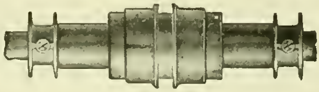


Single Clutch-Exterior



Double Clutch-Exterior

DIMENSIONS OF STANDARD SINGLE CLUTCHES

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2	2	$1\frac{7}{16}''$	$\frac{11}{16}''$	12 lbs.
4	3	$1\frac{11}{16}''$	$\frac{23}{32}''$	19 "
5	4	$1\frac{15}{16}''$	$\frac{23}{32}''$	27 "
6	5	$2\frac{3}{16}''$	$\frac{7}{8}''$	35 "
8	6	$3''$	$\frac{15}{16}''$	53 "

DIMENSIONS OF STANDARD DOUBLE CLUTCHES

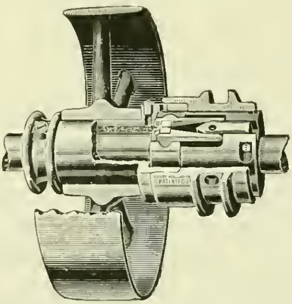
Clutch Size Number	Horse-power for each 100 R.P.M.	Largest Diameter Clutch will Bore	Throw D to Engage Clutch	Weight of Standard Clutch
2	2	$1\frac{7}{16}''$	$\frac{11}{16}''$	25 lbs.
4	3	$1\frac{11}{16}''$	$\frac{23}{32}''$	32 "
5	4	$1\frac{15}{16}''$	$\frac{23}{32}''$	43 "
6	5	$2\frac{3}{16}''$	$\frac{7}{8}''$	54 "
8	6	$3''$	$\frac{15}{16}''$	96 "

CONSTRUCTION

As seen by the illustration, this type of Clutch has but few parts and is very compact. A body fastened to the shaft carries a split ring in which are inserted a pair of levers. A curve-shaped wedge, which is made part of a shipper sleeve, forces the levers apart, expanding the ring, bringing its outer surface into frictional contact with the inner surface of the friction cup, the hub of which is made to suit requirements.

The leverage is so compounded that it requires but little pressure to operate the Clutch.

One screw which moves two taper blocks, set into the levers, adjusts the contact of the ring and cup to any tension. This is easily reached with a screwdriver through hole in the friction cup. The perfectly smooth shipper sleeve entirely covers the working parts so no dirt can get near them. The Double Clutch requires but little more space than the Single, and has two friction cups with hubs, on which can be mounted pulleys, cones, gears, etc., of any diameter and face.



Section Broken Away, Showing Clutch Engaged and Pulley Mounted on Hub of Friction Cup

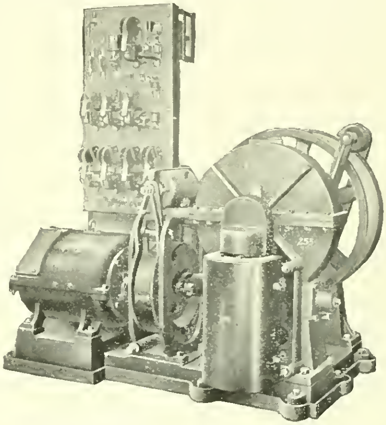
THE EASTERN MACHINERY CO.

NEW HAVEN, CONN.

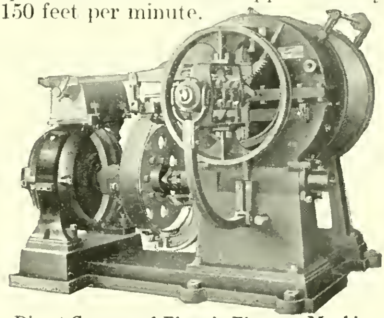
PASSENGER AND FREIGHT ELEVATORS

DIRECT CONNECTED ELEVATOR MACHINE AND CONTROLLER

For first-class elevator service at high or medium speeds, for either passenger or freight work, winding machines operated by full magnet control from switch in car are the most convenient, satisfactory and safe. They may be operated with direct current or alternating current. Where direct current is provided the machines can be arranged for two-speed operation. They can be built to handle a heavy load at a slow speed and a light load at a high speed. Or the slow-speed provision may be applied for convenient acceleration at the start and making stops easier and more accurate. Where alternating current is provided they cannot be satisfactorily arranged for two-speed control, and the car speed should not exceed approximately 150 feet per minute.



Direct Connected Elevator Machine and Controller for Car Switch or Automatic Push-Button Control



Direct Connected Electiic Elevator Machine for Shipper Rope Control

DIRECT CONNECTED ELECTRIC ELEVATOR MACHINE

For Freight or Passenger Service with Shipper Rope Control

This machine is designed for moderate speed passenger or freight service and arranged to be controlled by shipper rope passing through well hole, with or without wheel operating device in car as may be desired.

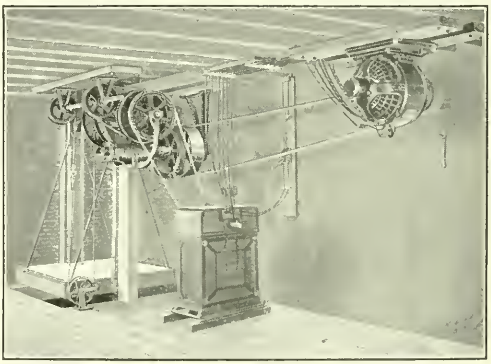
Either direct current or alternating current motors may be used, wound for any standard voltage.

This type of machine is also made compound geared, with single or double drum.

SINGLE BELT ELECTRIC ELEVATORS

This type of Elevator is especially useful for freight service and where car speed is not over 70 feet per minute. The operating parts consist of the usual worm gear winding machine driven with one belt from a compound wound reversing motor which runs only when the elevator is in motion. Either direct or alternating current motors built for the current in use may be employed.

Electric elevators of this type are less expensive than those with direct connected winding machines, and give very satisfactory service.



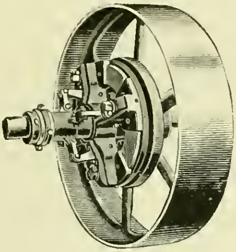
Single Belt Electric Elevator

THE EASTERN MACHINERY CO.

NEW HAVEN, CONN.

FRICTION CLUTCHES AND CUT-OFF COUPLINGS. FRICTION CLUTCH PULLEYS. FRICTION WINDING DRUMS.

THE FRISBIE PATENT FRICTION CLUTCH PULLEYS



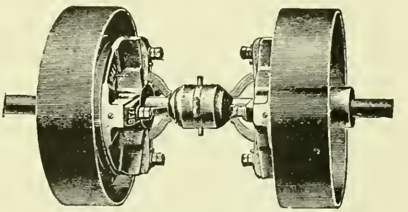
Single Pulley with Link Sleeve Friction

These pulleys operate in a perfect manner on all machinery moved by wheels, without loss of power, with no end thrust on the shaft, run without noise, and very little wear. They do away with all shifting of belts on tight and loose pulleys. They are simple in construction, readily understood and easy to adjust. They are equally good for high speed or low speed shafting, for heavy or light work. The variety of application is entirely unlimited and they are a source of profit wherever used.

They are in successful operation on countershafts and line shafts in factories of all descriptions. They are in use in rubber mills, brass mills, iron rolling mills, electric light stations, cotton mills, bleacheries, grain elevators, coal elevators, etc., etc.; on mining machinery, pile drivers, brick machinery.

We make no pretensions for our clutches that cannot be justified by their record. They do not vary from a uniform grade of excellence in construction, their superior standing being maintained by continued effort and well tested improvements. Each part is finished to templates or jigs in a first-class manner and each part interchangeable.

CONSTRUCTIONAL FEATURES



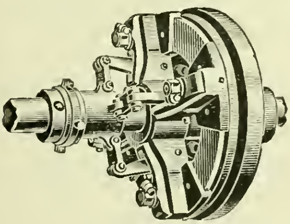
Pair of Friction Pulleys with Double Cone Sleeves

The pulley runs loose on the shaft with a renewable bushing through the hub, which takes all the wear.

The V friction ring is cast onto the arms of small pulleys, as shown in the views, and bolted onto the larger ones. The system of levers in the clutch spider, which is keyed solidly to the shaft, together with the friction shoes inside the ring, form the operating mechanism.

Movement of the sliding sleeve operates the latches which move the heavy dogs, and by means of the shoe bolts draws the four friction surfaces of the pulley and spider together in positive and powerful contact.

The leverage being great, only a few pounds' pull is required on the sleeve to exert enormous pressure on the friction surfaces. The amount of pressure is regulated by the clamp nuts on the shoe bolts, which also take up lost motion caused by wear. Notice that there are four friction surfaces and consequently a much more powerful friction grip than with other clutches.



Cut-Off Coupling

The shoes and spider are shod with thoroughly seasoned maple. End thrust on the shaft, so often noticed on other clutches, is also entirely eliminated.

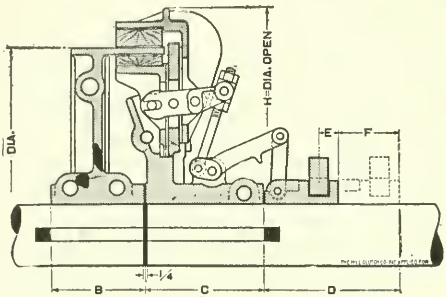
We have on hand at all times a complete stock of the smaller parts of our clutches and make a special point of quick deliveries.

THE HILL CLUTCH CO.

CLEVELAND, O.

New York Sales Office, 50 Church St.

A COMPLETE LINE OF POWER TRANSMISSION MACHINERY FOR BELT AND ROPE DRIVES, INCLUDING THE WELL KNOWN PATENTED HILL FRICTION CLUTCH (SMITH TYPE) AND COLLAR OILING BEARINGS, BRIEFLY DESCRIBED BELOW.

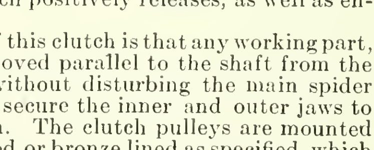


No. HP at 100 R.P.M. *	Equivalent Shaft Diam.	Maximum Stand. Bore	Extreme Bore of Mech.	Space on Shaft B	C	D	H
9	$1\frac{3}{16}$	$2\frac{3}{4}$	$3\frac{1}{2}$	3	$4\frac{1}{8}$	5	15
12	$1\frac{15}{16}$	$3\frac{1}{4}$	4	$3\frac{1}{2}$	$4\frac{3}{4}$	$5\frac{1}{4}$	$17\frac{1}{2}$
15	$2\frac{3}{16}$	$2\frac{1}{2}$	$4\frac{1}{2}$	4	5	$5\frac{1}{2}$	20
20	$2\frac{7}{16}$	3	5	$4\frac{1}{2}$	$5\frac{5}{8}$	$7\frac{1}{4}$	$22\frac{1}{2}$
27	$2\frac{11}{16}$	4	$5\frac{1}{2}$	5	$6\frac{3}{8}$	$7\frac{1}{2}$	$24\frac{3}{4}$
35	$2\frac{15}{16}$	4	6	$5\frac{1}{2}$	$7\frac{1}{8}$	8	$27\frac{1}{2}$
45	$3\frac{3}{16}$	$4\frac{1}{2}$	7	6	$7\frac{1}{2}$	$8\frac{1}{2}$	$29\frac{1}{2}$
60	$3\frac{7}{16}$	$4\frac{1}{2}$	7	6	$7\frac{1}{2}$	$8\frac{7}{8}$	$29\frac{1}{2}$
75	$3\frac{11}{16}$	5	$7\frac{1}{2}$	$6\frac{3}{4}$	8	$8\frac{3}{4}$	33
90	$3\frac{15}{16}$	5	8	7	$8\frac{1}{2}$	$9\frac{5}{8}$	$36\frac{1}{2}$
110	$4\frac{3}{16}$	$5\frac{1}{2}$	9	$7\frac{1}{2}$	$9\frac{1}{4}$	$9\frac{1}{2}$	41
140	$4\frac{11}{16}$	6	10	8	$9\frac{3}{4}$	$10\frac{7}{8}$	46
175	$4\frac{15}{16}$	6	11	9	11	11	50
230	$5\frac{1}{2}$	$6\frac{1}{2}$	12	10	12	11	57
350	6	7	12	10	12	11	57
480	7	$7\frac{3}{4}$	14	$11\frac{1}{4}$	14	12	64
625	$7\frac{1}{2}$	9	16	13	17	14	72
875	$8\frac{1}{2}$	$10\frac{1}{2}$	18	15	18	17	86
1300	10	12	18	18	20	20	98

The Smith Type of Hill friction clutches are built in 19 sizes ranging in capacity from 9 to 1300 horse power at a 100 R. P. M., and have 3, 4 and 6 arms according to their capacity. The friction surfaces are wood against iron, which is a combination offering great frictional resistance and the shoe area is exceptionally large. The action of the clutch mechanism is positive, no springs being used. The sectional view shows the toggle connection from the cone to the jaws, which positively releases, as well as engages the friction surfaces.

A noteworthy feature in the design of this clutch is that any working part, including the inside jaws, may be removed parallel to the shaft from the mechanism side. This can be done without disturbing the main spider casting or pulley, as bolted gib guides secure the inner and outer jaws to the spider as shown in the illustration. The clutch pulleys are mounted upon split removable sleeves, babbitted or bronze lined as specified, which can readily be replaced without disturbing the pulley or clutch.

HILL COLLAR OILING BEARINGS



In the Hill Collar Oiling bearings instead of depending upon a loose ring or chain for conveying oil to the journal, a fixed collar is employed.

Oil stored in large reservoirs in the bottom of bearing is continuously and positively elevated to the top reservoirs by the means of a heavy split collar clamped to the shaft. From the upper reservoirs the oil flows by gravity over the entire bearing surface.

Three or four revolutions of the shaft and the bearings are flooded.

It is not only in the positive and copious means of oiling that the Collar Oiling bearing gains in efficiency, for the collar also serves as a thrust collar and operates in a bath of oil and thrusts against babitted seats. On this account no outside collars are required unless the end thrust is extremely severe. All other types of bearings require outside shaft collars which bear against iron with no lubrication.

THE METALINE COMPANY

Corporate name changed from
NORTH AMERICAN METALINE CO.
April 10, 1912

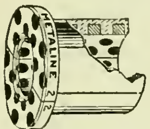
WEST AVE. NEAR BORDEN, LONG ISLAND CITY, N. Y.

METALINED OR OILLESS BEARINGS AND BUSHINGS

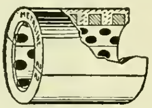
Metaline is composed of metallic oxides and other substances reduced to an impalpable powder and then solidified in hardened steel moulds under great pressure into short length plugs 3/16 in., 1/4 in. and 5/16 in. in diameter.

These plugs are inserted into holes drilled in divided bushings of gun metal bronze, phosphor bronze, or composition metal of good quality.

The two halves of the bushing having been soldered together and then machined all over to specified finished dimensions, are separated and holes drilled into the bearing surface—not all the way through the wall of the bushing—intowhich the Metaline plugs are tightly fitted and then filed flush with the bearing surface, care being taken to see that the spacing of the plugs is such that they will overlap or break joints, particularly along the line of motion.

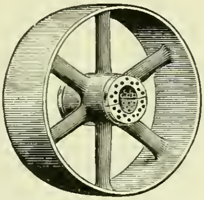


Flanged Bushing for loose pulleys or for boxes having an end or collar bearing



Plain Bushing for boxes or pulley block sheaves where there is no end bearing

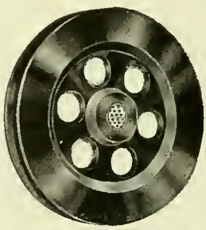
"METALINE"
(Trade Mark)
Registered in United States Patent Office, Act of Congress
Approved February 20, 1905



Loose pulley after being fitted with a set of two metalined flanged bushings

Bearings fitted with plugs of Metaline as described above are self-lubricating, being positively oilless; indeed no oil or other lubricant should be used.

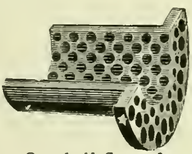
It has been proved that they last for many years, and, if the Metaline plugs are renewed before over-much wear of the bearing surface has taken place, the life of the bushing or bearing will be very greatly prolonged.



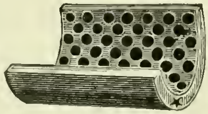
Sheave fitted with plain or unflanged metalined bushing

Cleanliness is a very desirable feature, which with the elimination of the danger of fire, a risk attending the use of fluid or semi-fluid lubricants in the other types of bearings, should particularly commend the use of Metaline.

It is conceded by the manufacturers that metalined bearings are not suitable for some lines of service; but it is claimed that these bearings give unusual satisfaction for tackle blocks, wire rope and tramway sheaves, loose pulleys, friction clutch pulleys, idler and mule pulleys, elevator pulleys and other places where the bearing revolves around the shaft; line and counter shaft boxes, floor stand boxes, ventilating fans, small motor bearings, etc.



One-half flanged bushing

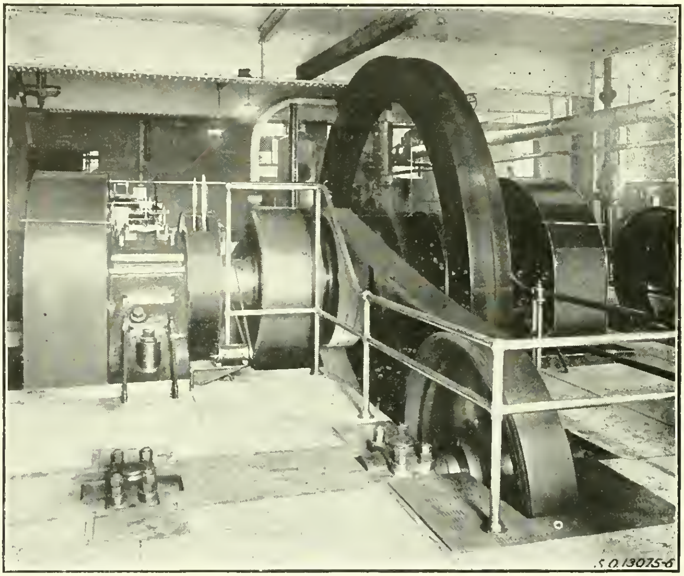


One-half plain bushing

MORSE CHAIN COMPANY

ITHACA, NEW YORK

MORSE SILENT RUNNING HIGH-SPEED CHAINS AND SPROCKETS



The Morse Silent-Running Power Chain is essentially a steel belt made of flat links so shaped as to form teeth on one side of the chain, which engage with teeth cut in the sprocket wheel on which it runs.

It is used in place of belting or gears to transmit power for any purpose and is made in sizes varying from $\frac{1}{4}$ H.P. at 3000 R. P. M. to 3000 H.P. at slow rotative speeds, an aggregate of over 500,000 H.P. being now in successful daily operation.

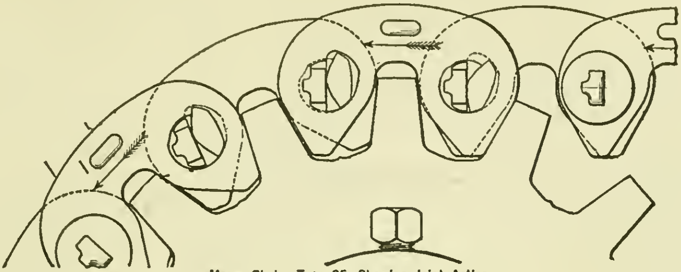
By its use power may be transmitted with a positive speed ratio on short centers, quietly and with an efficiency of nearly 99 per cent.

This high efficiency is due to the use of the Morse Frictionless Rocker Joint, which consists of two pins of hardened tool steel, each forming half of the joint and so shaped and held that as the chain bends, the rounded edge on one pin rocks upon the flat side of the other, thus substituting a rolling motion for the rubbing friction found in all other chain joints. When the chain is straight the flat seat pin bears against one of the flat faces of the rocker pin, so that it is only when the chain bends that the load comes upon the rounded edge of the rocker. This prevents undue vibration in the strands of the chain between the sprockets and reduces wear of the rolling base.

The chain should be lubricated with a heavy paste grease containing no solid matter.

The chains are made in a variety of widths to suit the power transmitted and in ten pitches, the number of revolutions of the smaller sprocket determining the pitch to be used, as shown by the following table:

(See next page)



Morse Chain, Type 25, Showing Joint Action.

MORSE CHAIN AND SPROCKET DATA

PITCH	$\frac{1}{2}$	$\frac{5}{8}$	$\frac{3}{4}$	$\frac{9}{10}$	$1\frac{2}{10}$	$1\frac{1}{2}$	2	3
Min. No. of Teeth — Small Sprocket Driver	13	13	13	15	15	17	17	17
Min. No. of Teeth — Small Sprocket Driven	17	17	21	25	29	29	31	35
Desirable number of teeth in small sprockets	15–17	17–21	17–21	17–23	17–23	17–27	17–31	19–31
Maximum number of teeth in large sprockets (See Note 3.)	99	109	115	125	129	129	129	131
Desirable number of teeth in large sprockets	55–75	55–75	55–85	55–95	55–105	55–115	55–115	55–115
To find pitch diameter of wheel multiply no. of Teeth by	.159	.199	.239	.2865	.382	.477	.636	955
Addendum. For outside diameter of sprockets 20 to 130 T. (See Note 1.)	.05	.06	.075	.09	.12	.15	.20	.30
Maximum R. P. M.	2400	1800	1200	1100	800	600	400	250
Tension per inch width chain — Small Sprocket Driver	80	100	120	150	200	270	450	750
Tension per inch width chain — Small Sprocket Driven	65	80	95	120	160	210	350	600
Radial clearance beyond tooth required for chain	0.50	0.62	0.75	0.90	1.2	1.5	2.0	3.0
Approximate weight of chain per inch wide, 1 foot long	1.00	1.20	1.50	1.80	2.50	3.00	4.00	6.00
Constants for Steel Pinions C	0.0045	0.0063	0.009	0.012	.023	.035	.058	145
Constants for Cast Iron Sprockets C	0.16	0.25	0.35	0.45	0.7	1.	2.	4.

Note 1. Number of teeth = T.
Exact Outside Dia. = D.
When T has less than 20 teeth, D = Pitch Dia.
When T has more than 20 teeth, D = Pitch Dia. + 2 × Addendum.

Note 2. Use sprockets having an odd number of teeth whenever possible.

Note 3. When specially authorized, a larger number of teeth than shown may be cut in large sprocket.

Note 4. Thickness of sprocket rim, including teeth, should be at least 1.2 times the chain pitch.

Note 5. The number of grooves in the sprocket, their width and distance apart varies according to pitch and width of chain. In every case leave the designing and turning of these grooves to the Morse Chain Company.

Note 6. The width of the sprocket should be $\frac{1}{8}$ to $\frac{1}{4}$ inch greater on small drives, and $\frac{1}{4}$ to $\frac{1}{2}$ inch greater on large drives than nominal width of the chain.

Note 7. The chain should have an even number of links and the wheels an odd number of teeth.

Note 8. Horizontal drives preferred; tight chain on top desirable for short drives without center adjustment.

Note 9. Adjustable wheel centers desirable for horizontal drives and necessary for vertical drives.

Note 10. Avoid vertical drives.

Note 11. Allow a side clearance for chain (parallel to axis of sprockets and measured from nominal width of chain) equal to the pitch.

Note 12. Desirable linear velocity for commercial service 1200 to 1600 feet per minute.

NORDYKE & MARMON CO.

INDIANAPOLIS, IND

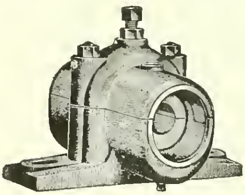
Estab. 1851.

FLOUR AND CEREAL MILL MACHINERY, ELEVATING, CONVEYING AND POWER TRANSMITTING APPLIANCES

Although best known as manufacturers of Flour and Cereal Mill Machinery, the Nordyke & Marmon Co. are also large manufacturers of Elevating, Conveying and Power transmitting appliances. We present herewith a partial list of our products in this line, and a few illustrations to show the symmetrical and powerful lines along which they are designed.

Our general price list No. 1020 contains brief descriptions and complete tables of prices, dimensions and weights.

We also issue descriptive catalogues as follows: Roller Mills, Bolting Machinery, Book on Mills (Feed Mill Machinery), Packers, Blending Machinery, Rice Mill Machinery, Special Corn Mill Machinery, Starch Mill Machinery, and numerous circulars describing special machines.



Ring Oiling Bearing

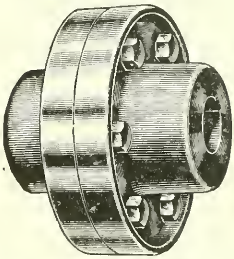
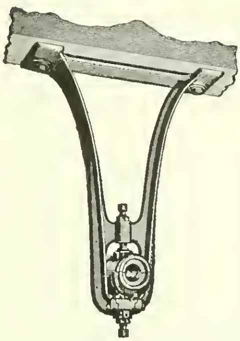


Plate Type Coupling



Adjustable Ball and Socket Drop Hangers
Double Brace, Ring Oiling Bearings

We contract to furnish complete mechanical equipment for flour mills, corn mills, cereal mills, starch and rice mills, with or without power plant from the smallest to the largest capacities, furnishing detailed building and machinery plans.

A large and complete stock of mill supplies is carried from which orders are promptly filled.

We solicit inquiries for prices, estimates and information.

Attachments, sprocket chain

Bearings, double, eccentric, elevator boot, flange, flat, floor, floor stand, hanger, journal, pedestal, pillow block, post, rigid flat, rigid vertical, ring oiling, roll feeder, step, take-up, universal, upright, vertical

Belt clamps

Belt conveyor appliances

Belt tighteners

Belting, canvas stitched, cotton, leather, rubber

Bevel gears

Boots, elevators—cast iron, galvanized iron, wood.

Brackets, wall

Buckets, elevator

Chain, sprocket

Clutches, friction, jaw

Cogs, wood

Collars, safety set

Conveyors, belt, flight, helicoid, spiral

Countershafts, variable speed

Couplings, clamp, cog, compression, conveyor, finger, flange, friction clutch, jaw clutch plate

Cups, elevator

Elevators

Frames, sectional wall

Gears, bevel, spur, mitres, internal

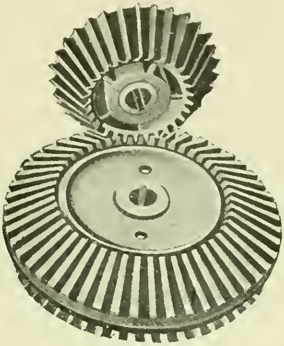
Hangers, conveyor, drop, post

Hardwood conveyor flights

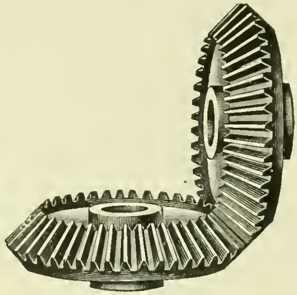
NORDYKE & MARMON COMPANY

INDIANAPOLIS, IND.

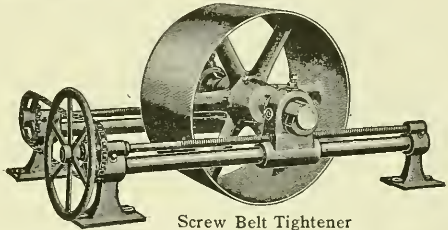
Heads, elevator: galvanized iron, sprinkler, standard
Hoisting crabs
Hoisting cranes
Hoisting screws
Jacks
Keyseating
Laces, belt
Link belt
Link belt attachments
Linings, conveyor
Manila transmission rope
May-Oborn chain
Movers, car
Pillow blocks
Plates, anchor, arch leveling, pulley, sole or base, toe, tram
Post hangers, adjustable, double rigid
Power grain shovels
Pullers, car
Pulleys, cast iron, clamp hub, flanged, friction clutch, rope, solid, split, tight and loose
Rack tighteners
Rolls, belt conveyor
Rope, Manila transmission
Rope, sheaves
Rope, wire
Scales
Set screws
Shafting
Sheaves, rope, rubber filled
Speed indicators
Stands, floor, pulleys
Take-up boxes
Tension carriages
Tighteners, belt
Tracks for tension carriages
Triple conveyor bearings
Troughing rolls and carriers
Vertical shaft bearings
Wall box frames
Weights for tension carriages
Wheels, sprocket
Wood boxes for conveyors
Wood shaft conveyor
Wrenches



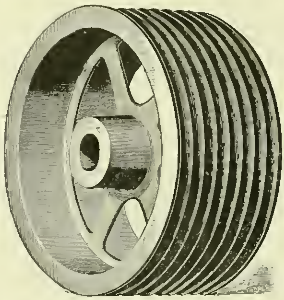
Bevel Mortise Gearing



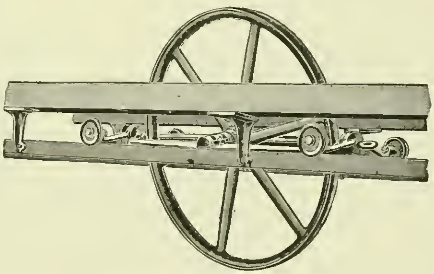
Mitre Gearing



Screw Belt Tightener
Horizontal and Upright



Finished Iron Sheaves
For Manila Rope Transmission



Horizontal Tension Carriage
Double Track

ONEIDA STEEL PULLEY COMPANY

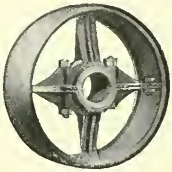
ONEIDA, NEW YORK

MANUFACTURERS OF HIGH GRADE STEEL PULLEYS

The ONEIDA has the best possible belt adhesion since the oval crown face fits the belt perfectly.

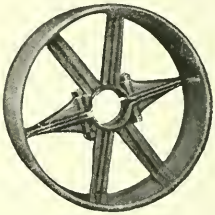
Being held to the shaft by compression the bolts may be drawn extremely tight making it practically a positive drive.

Owing to the blade like arms the ONEIDA has slight windage.



11 x 3 x $3\frac{1}{2}$

This pulley weighs but $\frac{1}{4}$ to $\frac{1}{3}$ as much as a cast iron pulley and thereby saves from $\frac{3}{8}$ to $\frac{2}{3}$ of the actual H. P. required to revolve a cast iron pulley.



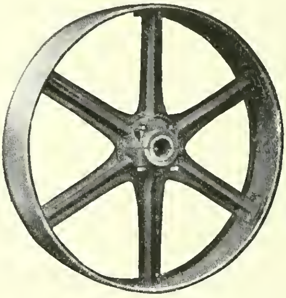
16 x 4 x $3\frac{1}{2}$

The particular advantage of the Oneida is that it is made in the greatest range of sizes of any steel pulley in the world, thus making it possible to equip any mill complete with one make of pulley. They may be made to fit any standard size shaft by means of a system of interchangeable bushing.

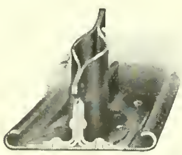
Range of sizes

Diameter - - - -	6″ to 126″
Face - - - -	2″ to 40″
Bore - - - -	$\frac{3}{4}$″ to $8\frac{1}{2}$″

Is made in split form and is thereby easily erected on shaft and does not necessitate the removal of other pulleys and hangers to be placed in position.



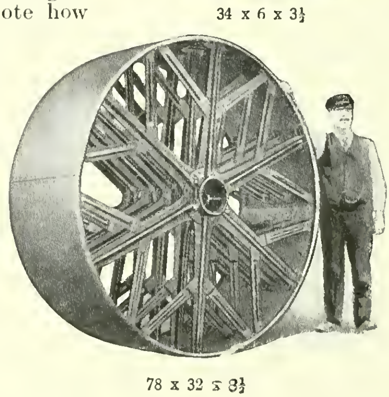
34 x 6 x $3\frac{1}{2}$



This illustration shows the fishplate reinforcement of rim and style of riveting to the arms. Note how the parts are made male and female. Impossible to bring to bear a shearing strain on the rivets that would cut them.

We also manufacture belt and conveyor pulleys, drums, elevator, head, tail and tripper pulleys, flange and special railroad pulleys.

Send for our large and complete catalogue.



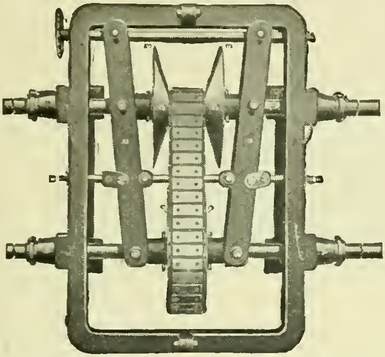
78 x 32 x $3\frac{1}{2}$

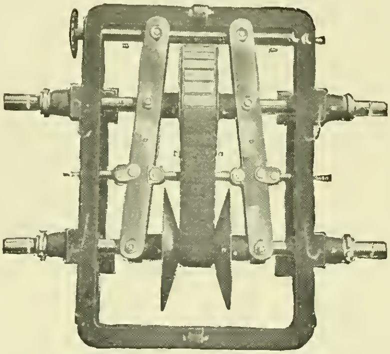
REEVES PULLEY COMPANY

COLUMBUS, IND.

Branch House: Clinton and Monroe Sts., Chicago

"THE REEVES" PATENT VARIABLE SPEED TRANSMISSION, PATENT WOOD-SPLIT PULLEYS, PATENT WOOD-SPLIT PULLEY CLUTCH, POWER TRANSMISSION APPLIANCES





"THE REEVES" VARIABLE SPEED TRANSMISSION

Construction and Operation. The essential feature is that two pairs of cone disks are spline mounted on two parallel shafts. These disks are operated by a pivoted bar which is operated by a screw in such manner that one pair of disks is brought together while the other pair is forced an equal distance apart. At the same time a uniform tension of the special belt is maintained. Efficiency from 80% to 95%, according to conditions of the service.

The inner sides or faces of the disks form a V-shaped groove into which is fitted an especially designed belt, having its bearing surface on the edges instead of the bottom, as with an ordinary belt.

One set of disks acts as driver and the other driven. As the disks are actuated so the belt assumes the large diameter on one pair of disks, it at the same time assumes the small diameter on the opposite pair, thus increasing or diminishing the speed of the driven shaft, and giving any speed between the two extremes of variation.

Installation. "The Reeves" Variable Speed Transmission is installed in the same manner as an ordinary countershaft and may be placed on the floor or suspended from the ceiling as desired.

Application. It may be applied to any machine or mechanical device whatever requiring variable speed, such as Iron Working Tools, Canning Machinery, Packing Machinery, Bakers' Machinery, Laundry Machines, Textile Machinery, Veneer Cutters, Dryers, Cement Machinery, Paper Making Machinery, etc.

Sizes. Made in sizes from 2 H.P. to 150 H.P. Speed Variation as great as ten to one, or less as required.

Catalogue on request.

"THE REEVES" WOOD-SPLIT PULLEY

"The Reeves" Wood-Split Pulleys are made in all sizes up to 30 ft. diameter. Being fitted with interchangeable bushings they may be changed from one shaft to another of different size at an expense of a few cents for a new bushing.

Stocks carried in all jobbing centers.

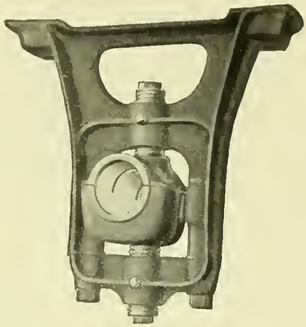
Catalogue on request.

T. B. WOODS SONS CO.

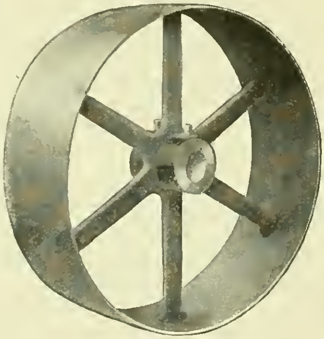
CHAMBERSBURG, PA.

MANUFACTURING ENGINEERS,
POWER TRANSMISSION MACHINERY

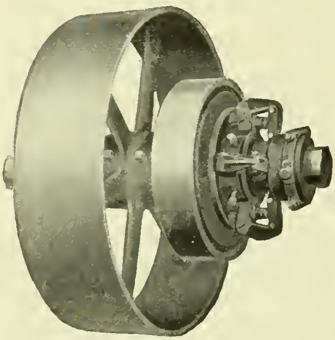
Base Plates, Plain and Adjustable.
Belt Clamps.
Belt Shifting Appliances.
Belt Tighteners.
Binder Frames, Single and Double Brace.
Bushings, Cast-Iron for Loose Pulleys, Phosphor Bronze, Patent Bronze Graphite.
Couplings, Collins Compression, Double Cone Vise Compression, Plate or Flange, Ribbed Compression, Ring Compression, Shifting Jaw Clutch, Solid Sleeve, Universal Giant Compression, Friction Cut-off.
Floor Stands.
Friction Clutches, Duplex, Split, Cut-off Couplings, Shifter Stands.
Girder Clamps.
Guide Pulleys.
Hangers, Extra Heavy Headshaft, Headshaft, Double Brace, Ring Oiling Ball and Socket, Peerless Four Point, Bracket-Ring Oiling Patented.
Mule Pulley Stands, Stationary and Adjustable.
Pillow Blocks, Ring Oiling Ball and Socket, Peerless Four Point, Plain Rigid, Ring Oiling Rigid.
Pulleys, Single Belt Solid, Double Belt Solid, Split, Clamp Hub, Tight and Loose, Flange.
Quills.
Quill Bearings.
Rope Transmission.
Set Collars, Solid and Split.
Shafting.
Step Bearings, Plain and Adjustable.
Vertical Shaft Bearings.
Wall Brackets.
Wall Frames, Steel Top, Plain and Adjustable; Cast Iron, Plain.
Sheaves.
Tension Carriages.
Rope.



Hanger



Pulley



Universal Giant Friction Clutch Pulley

UNIVERSAL GIANT FRICTION CLUTCH WITH EXTENDED SLEEVE

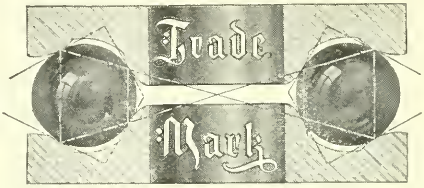
This clutch is made with an extended sleeve of standard diameter, so that an ordinary pulley, gear, rope sheave or sprocket can be used by simply keying it on sleeve of clutch. It is only necessary that the bore be same as diameter of sleeve, just as if bored to fit a line shaft. This feature eliminates the expense and delay of making up special pulleys, as is usually required.

The Universal Giant Friction Clutch is designed so that the outer rim covers and protects the friction surfaces from dust, dirt or any foreign substance. The life of all wearing parts is thus greatly prolonged and the clutch is made especially valuable for use in cement mills, phosphate factories, elevators, or any place where dust or gritty substances are afloat in the air.

AUBURN BALL BEARING COMPANY

22 ELIZABETH STREET, ROCHESTER, N. Y.

AUBURN BALL THRUST BEARINGS; AUBURN ANNULAR BALL BEARINGS; AUBURN STEEL, BRASS, AND BRONZE BALLS.



Auburn Ball Thrust Bearings are especially adapted for High Speeds and Heavy Loads in a small space due to Auburn Patented Four Point Contact Cone Principle, illustrated by the trade mark. Specially selected tool steels properly hardened through and through in the balls and races, together with careful grinding and polishing, make Auburn Bearings most durable.

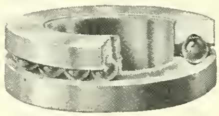
Auburn Ball Thrust Bearings are used extensively for Boring, Drilling, Milling and Screw Machinery; Lathes, Elevators and Jacks; Hydraulic and all Transmission Machinery wherever the thrust of a rotating part is to be taken care of.

AUBURN STYLE T-100 BALL THRUST BEARING.

Auburn Style T-100 bearing is a self contained ball thrust bearing. The outside retaining sleeve is attached to the lower race of the bearing with the upper race free to rotate, yet held in place. This sleeve furnishes a protection to the balls from dust and dirt, as well as making the bearing a unit. This feature greatly facilitates the assembling of the bearing on the machine and does away with the loss of balls in transit and during the operation of installing. It is a style for use in exposed places where some protection to the bearing is desired.

AUBURN STYLE T-114 BALL THRUST BEARING.

Where there is a housing to protect the bearing this Auburn Style T-114 is desirable. It is also self-contained and a unit with the advantage of easy assembling on the machine. The retaining sleeve is attached to the bore of one race, leaving the other free to rotate, yet holding same in position. This is a style to use where a good circulation of oil must be had.



AUBURN STYLE T-101 BALL THRUST BEARING.

When the self-contained feature is not desired Style T-101 Ball Thrust Bearing is furnished. This comprises two grooved ball races filled with balls.

Auburn Ball Thrust Bearings are carried in stock for immediate shipment covering a range of shafts up to five inches in diameter, in light and heavy types. Larger sizes with load capacities up to 200,000 pounds can be furnished promptly.

Bearings specially designed to meet unusual conditions of service can be made promptly. Write for bulletin.

THE HESS-BRIGHT MFG. CO.

PHILADELPHIA, PA.

HB MANUFACTURERS AND IMPORTERS OF ANNULAR AND THRUST BALL BEARINGS **DWF**

HESS-BRIGHT (DWF) BALL BEARINGS

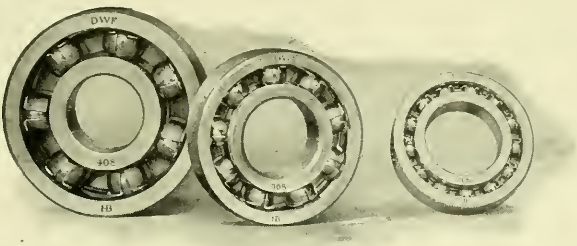
are used in

Lineshaft Hangers	Trolley Cars
Machine Tools	Woodworking Machinery
Dynamos and Electric Motors	Flour Milling Machinery

Automobiles, etc.

Special literature on request describing these and other applications.

Aside from the economy in power which they make possible, Hess-Brights effect important savings in repair and upkeep charges, due to the fact that wear is virtually absent.



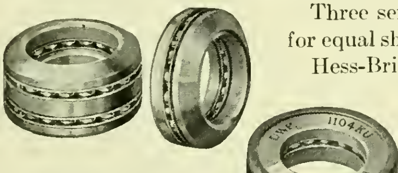
HESS-BRIGHTS of "heavy," "medium" and "light" series, for same shaft size

ANNULAR BEARINGS

Made regularly in sizes up to 110 mm. (4.3307 inches) shaft diameter. Special sizes to order if quantity is sufficient.

Three series: "Heavy," "Medium" and "Light," for equal shaft sizes. Regular and high-speed types.

Hess-Bright Annular Bearings are so constructed that the sides of the races are unbroken. This fact has an important bearing on durability.



HESS-BRIGHT THRUST BEARINGS

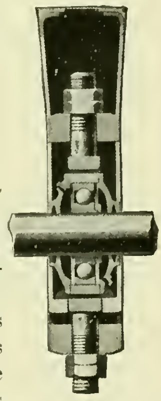
THRUST BEARINGS

Made regularly in sizes up to 140 mm. (5.5118 inches) shaft diameter. Larger sizes on special order.

Two series: "Medium" and "Light."

One-direction and two-direction types, with or without aligning washers, though the use of such washers is recommended.

Our Engineering Department is at the service of our customers for recommendations as to type, size, and mounting of bearings to secure best results. All intending users of Hess-Brights are urged to avail themselves of this service, for which no charge is made.



Section of Ceiling Hanger

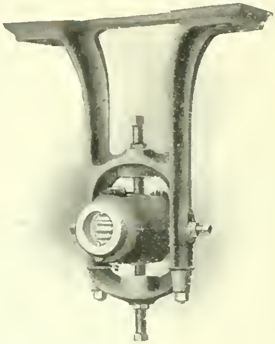
HYATT ROLLER BEARING COMPANY

NEWARK, NEW JERSEY

HYATT FLEXIBLE ROLLER BEARING LINE SHAFT BOXES

Actual service covering a period of over 15 years has demonstrated the Hyatt Flexible Roller Bearing pre-eminently successful for line shaft work.

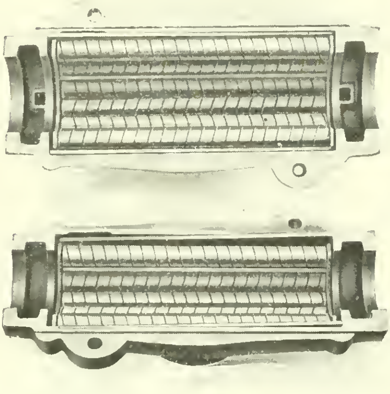
The distinctive feature of the Hyatt Flexible Roller Bearing is the roller, which is made from a strip of steel wound into a coil or spring of uniform diameter. The greatest advantage of a roller of this construction is in its flexibility, enabling it to present at all times a bearing along its entire length, resulting in a uniform distribution of load on the roller itself, as well as the surfaces on which and in which it operates. All tendency, therefore, to distortion of these surfaces is entirely eliminated, for the roller will adjust itself to all irregularities that may be present, there being no necessity for hardening the various parts of the bearing, any good steel surface satisfactorily answering all requirements.



Four-Point Set Screw

It will also be seen from its construction that the roller essentially acts as an oil reservoir, while the spiral and roller together perform the function of an oil carrier, thereby assuring perfect lubrication of all parts at all times, making it possible to operate the bearing for a considerable interval without attention.

By varying the diameter of the roller as well as the thickness, width and character of stock from which it is made, it is possible to so vary its nature as to enable it to operate under the most varied conditions, from the heaviest load on one hand to the highest speed on the other.



Halves of Split Hyatt Roller Bearing Box for Line Shafting

The box is of iron, cast in two parts and lined with steel. When assembled it is held by two large French-head screws, one at each end at opposite sides. At the top are automatic self-closing oil cups, eliminating foreign matter. At each end of the box are oil wells. A wiper is placed in the lower side, and as the oil works outward on the shaft it is caught by the wipers, and is returned to the bearings to be again taken up by the rollers.

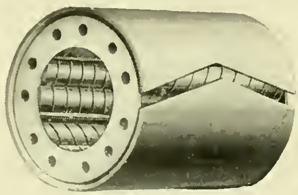
Numerous tests have been made under all conditions of speed and load and in all classes of equipment, and in every instance have justified our claims of a saving in power from 10 to 25 per cent., depending upon local conditions.

Write for Bulletin 400C.

HYATT ROLLER BEARING COMPANY

NEWARK, NEW JERSEY

HYATT STANDARD and HIGH DUTY BUSHINGS



Commercial Type

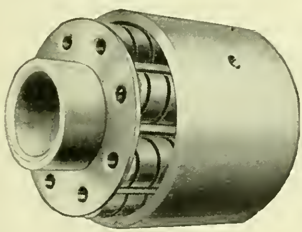
The Hyatt Roller Bearing as applied to machinery in general is offered in two separate and distinct types—the Commercial Type, its original form, and the High Duty Type, a subsequent development. Both types are based upon the same fundamental principle of the Hyatt Flexible Roller, but differ so far as manufacture is concerned in the character, type and treatment of the material used, and in their commercial applications, in the conditions of speed and load involved, the limitations in sizes, the character of the apparatus in question and the particular views on the part of the designer or purchaser as to the type of bearing considered preferable.

The advantages peculiar to Hyatt Bushings may be enumerated as follows:

1. The Hyatt Bearing is applicable to all speeds and loads; by employing light flexible rollers we obtain a bearing suitablè for light work; by employing heavier and stiffer rollers we meet conditions involving heavy duty at slow speed.

2. The Hyatt Roller cannot crush, as it is designed to support the load with a liberal factor of safety.

3. The flexibility of the Hyatt Roller insures a full line of contact, as compared with the series of points presented by either solid rollers or balls. Consequently a uniform distribution of the load is obtained and there is no tendency to distort the metal of the journal or casings.



High Duty Type

4. The Hyatt Roller acts as a natural oil reservoir, and the alternated right and left spirals act as oil carriers.

5. The Hyatt Roller has shown, under tests, a lower coefficient of friction, hence higher efficiency, than any other design.

The special bushings, heretofore furnished in small quantities, have been high priced because of the necessarily high cost of manufacturing and correspondingly high percentage of overhead expense which they had to carry.

We became convinced that adopting a number of standard sizes, manufacturing them in large quantities, and carrying them in stock, would enable us to sell these standard bushings in limited quantities at a very moderate price.

We are now in a position to furnish Hyatt bushings in any quantities at reasonable prices. They are designed for all conditions, speeds and loads, and therefore be suitable for all classes of machinery. These standard commercial bushings will be supplied in one-half inch lengths when the quantity justifies making them up. The high-duty bushings in sizes as per Bulletin 305.

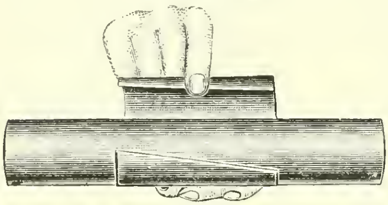
ROYERSFORD FOUNDRY AND MACHINE CO.

52 N. 5TH ST., PHILADELPHIA, PA.

POWER TRANSMISSION MACHINERY AND SELLS ROLLER BEARINGS

SELLS ROLLER BEARINGS — THE SPLIT BEARING

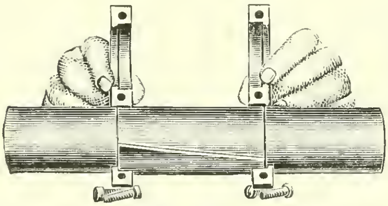
Wear of the shaft is prevented in The Sells Roller Bearings by a high-carbon steel bushing upon which the rollers operate. This bushing is split diagonally so the rollers can pass from one half to the other without breaking down the edges at the splits. Two split collars clamp the two halves of the bushing securely to the shaft. By varying the thickness of these bushings, the Sells can be adapted to fit different diameters of shafting.



The Split Bushing

THE SPLIT COLLAR

The Split Collars not only clamp the bushing to the shaft, but also retain the roller structure between them. As these collars revolve with the roller structure, friction and wear caused by end thrust are reduced to a minimum. The shaft revolves faster than the roller structure, so that the collars assist the roller structure to revolve, and still further minimize friction.

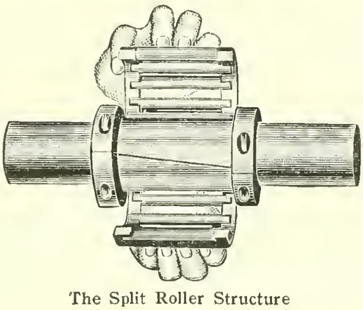


The Split Collar

THE SPLIT ROLLER STRUCTURE

The roller structure is very rigid. It contains the rollers, separates them from each other, and insures alignment with the shaft.

The Rollers are case hardened steel, accurately ground to size, and being hard on the outside and soft on the inside, they are not brittle and therefore no breakage of rollers occurs.

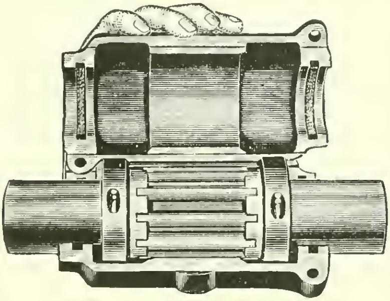


The Split Roller Structure

THE SPLIT BOX

The Split Box is made of a special gray iron casting, carefully machined. It is split with a milled tongue and grooved joint and the halves are bolted together.

Reservoirs for lubricant are provided and grease and drain holes are conveniently placed. Felt packing at the ends of the box retains the lubricant and excludes dust.



The Split Box

SELLS ROLLER BEARING BOXES

Size of Shaft, Inches	Length of Box. Inches	Width of Box, Inches	Height of Box. Inches
$\frac{15}{16}$ & 1	$6\frac{7}{8}$	3	$3\frac{5}{16}$
$1\frac{3}{16}$ & $1\frac{1}{4}$	$6\frac{7}{8}$	3	$3\frac{5}{16}$
$1\frac{7}{16}$ & $1\frac{1}{2}$	$7\frac{1}{4}$	$3\frac{1}{4}$	$3\frac{9}{16}$
$1\frac{11}{16}$ & $1\frac{3}{4}$	8	$3\frac{3}{4}$	$4\frac{3}{16}$
$1\frac{15}{16}$ & 2	$8\frac{3}{8}$	$3\frac{15}{16}$	$4\frac{9}{16}$
$2\frac{3}{16}$ & $2\frac{1}{4}$	$9\frac{7}{8}$	$4\frac{1}{2}$	$5\frac{3}{16}$
$2\frac{7}{16}$ & $2\frac{1}{2}$	$10\frac{1}{4}$	$4\frac{3}{4}$	$5\frac{9}{16}$
$2\frac{11}{16}$ & $2\frac{3}{4}$	$10\frac{3}{4}$	$5\frac{3}{8}$	$6\frac{1}{8}$
$2\frac{15}{16}$ & 3	$11\frac{1}{16}$	$5\frac{1}{2}$	$6\frac{1}{8}$
$3\frac{3}{16}$ & $3\frac{1}{4}$	$11\frac{7}{8}$	$5\frac{15}{16}$	$6\frac{5}{8}$
$3\frac{7}{16}$ & $3\frac{1}{2}$	$12\frac{3}{8}$	$6\frac{1}{8}$	$6\frac{7}{8}$

For heavy duty on head and line shafts we recommend the double box described at bottom of next page.

ROYERSFORD FOUNDRY AND MACHINE CO.

POWER TRANSMISSION MACHINERY AND SELLS ROLLER BEARINGS

Drop Hangers. Post Hangers and Pillow Blocks with universal adjustment are now so generally admitted to be superior to any other type, that it is needless to advance any argument in favor of their use.

Add to frames of this type a Sells Roller Bearing Box and you have practically a frictionless, non-wearing bearing.

The illustrations on this page show how Sells Roller Bearing Boxes are applied to Royersford drop hangers, post hangers and pillow blocks. They may also be substituted for old style boxes of equivalent shaft diameters, in most standard makes of hangers, post hangers, or pillow blocks.

As the boxes are split, the substitution is simple and inexpensive. Several hundred feet of line shafting can be changed over night, without interrupting the running of the plant during the day.

If Roller Bearings are an economy in all other power-transmitting work on account of their anti-frictional qualities, why will they not be just as efficient on shafting which runs steadily for ten hours a day in most plants.

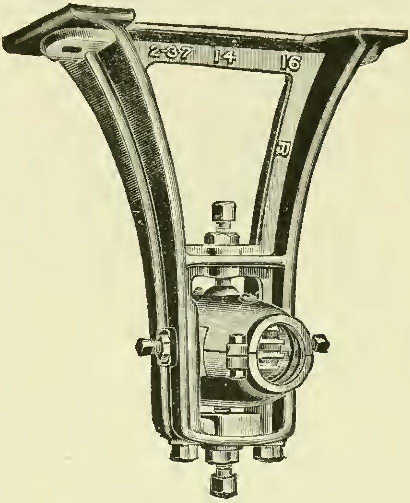
If it requires power to overcome friction and steam to create power, why not use Roller Bearings and prolong the life of your equipment, as well as reduce the consumption of fuel necessary to create the power.

We guarantee a reduction in the friction load of from 40 per cent to 60 per cent, which annually will more than pay for the cost of substitution. Further information on request.

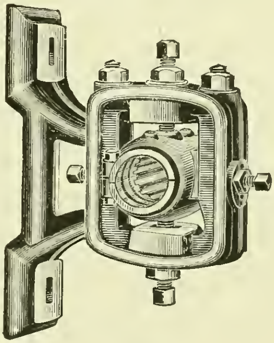
DOUBLE BEARING FOR HEAVY DUTY

The SELLS Double Box is similar to the regular Sells Bearings, except two roller structures are used to obtain longer bearing surface, when bearing is used on head shafts or on line shafts adjacent to main driving pulley, and especially where most of load is on one bearing.

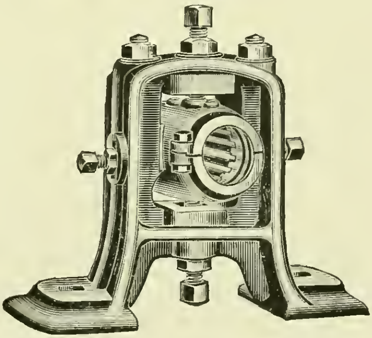
Size of Shaft, Inches	Length of box, Inches	Width of Box, Inches	Height of Box, Inches
$1\frac{15}{16}$ & 2	13	$3\frac{15}{16}$	$4\frac{9}{16}$
$2\frac{3}{16}$ & $2\frac{1}{4}$	$13\frac{3}{4}$	$4\frac{1}{2}$	$5\frac{3}{16}$
$2\frac{7}{16}$ & $2\frac{1}{2}$	$14\frac{3}{8}$	$4\frac{3}{4}$	$5\frac{9}{16}$
$2\frac{11}{16}$ & $2\frac{3}{4}$	$15\frac{1}{4}$	$5\frac{5}{16}$	$6\frac{1}{8}$
$2\frac{15}{16}$ & 3	$15\frac{7}{8}$	$5\frac{1}{2}$	$6\frac{1}{8}$
$3\frac{3}{16}$ & $3\frac{1}{4}$	$17\frac{1}{16}$	$5\frac{15}{16}$	$6\frac{5}{8}$
$3\frac{7}{16}$ & $3\frac{1}{2}$	$17\frac{13}{16}$	$6\frac{1}{8}$	$6\frac{7}{8}$



Drop Hanger



Post Hanger



Pillow Block

DURABLE WIRE ROPE COMPANY

93-95 PEARL STREET, BOSTON, MASS.

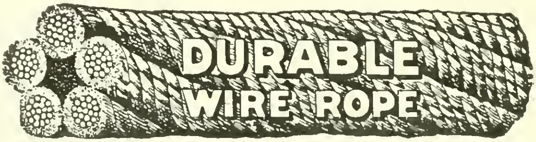
Agencies

Hegeman & Ward
43 South St., New York

Fairbanks Co.
Baltimore

Durable Wire Rope Co.
165 W. Lake St., Chicago

John A. Roeblings Sons Co.
San Francisco, Portland, Seattle



This is a rope composed of wire strands, each strand being served with a specially prepared hemp marline, and the whole laid up around a manila centre. This construction makes the rope more flexible than plain wire and more durable than plain wire or manila, as it is rust and rot proof.

GENERAL USAGES

Owing to its great flexibility and freedom from wear and rust **Durable Wire Rope** is especially adapted for General Hoisting, Car Hauls, Crane and Derrick Ropes, Grain Shovel Ropes, Saw Carriages, Slings.

MARINE USAGE

Owing to its protection from rust and rot **Durable Wire Rope** is particularly adapted for Boat Falls, Cargo Whips, Heavy Purchases, Topping Lifts, Guy Tackles, Slings, Buoy Lines and Tow Lines, Fasts and Rigging.

ROPE TRANSMISSION

Due to its high coefficient of friction and strength, **Durable Wire "Jupiter" Transmission Rope** is particularly well adapted for Rope Drives, especially the American System. A glance at the comparative table given below will demonstrate the superiority over manila ropes.

Table Showing HORSE-POWER Transmitted (per Wrap) by MANILA (M) and JUPITER (J) Rope, Diameter of Sheaves in Inches; Weight per Foot of Manila Rope; Weight pei Foot of Jupiter.

Diameter of Rope in inches.	Speed of the Rope in Feet Per Minute																Diameter of Sheaves Inches	Weight per Ft. Manila Rope.	Weight per Ft. Jupiter Rope.
	1,500		2,000		2,500		3,000		3,500		4,000		4,500		5,000				
	M	J	M	J	M	J	M	J	M	J	M	J	M	J	M	J			
5/8	2.3	13	3.2	18	3 6	22	4 2	25	4.6	28	5 0	31	5.3	33	5.3	35	24	.16	.40
3/4	3 3	24	4.3	31	5 2	38	5 8	45	6 7	52	7.2	58	7.7	62	7.7	67	36	.20	.54
7/8	4 5	30	5.9	40	7 0	49	8 2	58	9.1	66	9 8	74	10.8	80	10.7	86	42	.33	.70
1	**5.8**	**36**	**7.7**	**48**	**9 2**	**59**	**10 7**	**70**	**11.9**	**80**	**12.8**	**90**	**13 6**	**97**	**13.7**	**105**	48	**.42**	**.80**
1 1/8	7.5	53	9.9	69	11.7	84	13.7	100	15.4	114	16.4	128	17.4	138	17.7	148	60	.47	1.12
1 1/4	9.2	69	12.1	92	14.3	114	16 8	135	18.6	159	20.0	173	21 2	188	21.4	204	72	.60	1.29
1 3/8	**11 2**	**80**	**15 0**	**105**	**17.5**	**130**	**19.9**	**160**	**22 7**	**182**	**24 4**	**205**	**25.9**	**230**	**26 1**	**250**	72	**.70**	**1.66**
1 1/2	13 1		17.4		20.7		23.1		26.8		28.8		30.6		30.8		78	.80	
1 3/4	18.0		23.7		28.2		32.8		36.4		39.2		41.5		41.8		78	1.15	
2	23.1		30.8		36.8		42 8		47.6		51 2		54 4		54 8		78	1.35	

JUPITER ROPE WILL RUN ON MANILA ROPE SHEAVES

WATERBURY COMPANY

80 SOUTH STREET, NEW YORK CITY

MANILA AND SISAL ROPE; WIRE ROPE OF EVERY DESCRIPTION; MUSIC WIRE; OIL WELL LINES, BOTH WIRE AND FIBRE; RUBBER INSULATED WIRES; LEAD COVERED CABLES

WATERBURY

TRANSMISSION ROPE

Made from highest grade of Selected Cebu Manila Hemp.

This Rope is especially adapted to power driving, hoisting and other purposes where conditions require a superior Rope.

GORE CONSTRUCTION WIRE ROPE (Patented)

Made 6 strands, 19 to 61 wires to strand, according to size.

Furnished in Crucible Cast Steel, Extra Strong Cast or Plow Steel stock. The strands in this class of Rope are wound with flat wires having convex edges, which wires take the abrasion on crown of strands. The initial factor of safety is maintained longer in Gore Construction Patent than in any other class of Rope. For severe usage in Hoisting and Haulage equipments, Dredging and Steam Shovel service.

FIBRECLAD WIRE ROPE

A combination Rope of Wire and the best grade of Tarred Russian Hemp Marline—used extensively by the United States Government, Shipbuilding Plants, Power Plants, Towing and Transportation Companies, Stevedores, Coal Companies, and in fact for all Hoisting purposes and other general uses.

NON-ROTATING ROPE

Manufactured in various grades of steel to meet working conditions. Non-Spinning or Non-Rotating Ropes are particularly adapted to work where single lines are used, and overcome the tendency of Ropes to spin, twist, or kink, with or without load.

ELECTRIC WIRES AND CABLES

Any Insulation—For Any Service

Rubber—Code-Intermediate—30% Para
Braided or Lead Encased.

Varnished Cambric—Weatherproof Braided, Flameproof Braided Station Cable, Lead Encased Underground Cable.

Paper—Lead Encased. Dry or Saturated Core.

Submarine Cables for any Service—
We design and install complete Aerial and Underground Systems.

BOSTON BELTING COMPANY

256 Devonshire St., BOSTON

100 Reade St. New York	90 Pearl St. Buffalo	169 W. Lake St. Chicago	55 First St. San Francisco	105 First St. Portland, Oregon

BELTING HOSE PACKING

TRANSMISSION BELTING

Brands—Red Frictioned, Imperial stitched, Elmwood, Boston, Niagara, Trimount, Universal.

Adapted for all conditions of service; made from qualities and weaves of duck and grades of rubber which assure maximum service and economy.

GUTTA-BALATA BELTING; a high-grade textile belt, adapted for power transmission, also for conveying; so constructed that belts four-ply and heavier have absolutely seamless faces, and either side can be run next the pulleys; not injuriously affected by moderate quantities of oil or grease.

EELSKIN SOLID WOVEN COTTON BELTING made in three weights—single, double and triple; a solid, multiple-woven belt, woven under high tension, from high-grade yarns; thoroughly impregnated with a preservative compound; strong, flexible, adapted for service under practically all conditions.

CONVEYOR BELTING

Made all widths and thicknesses, with regular rubber cover, or extra thick rubber cover on one or both sides, and reinforced edges; adapted for use on straight or troughing pulleys, for carrying coal, ores, grain, gravel, sand, and other materials.

HOSE, rubber, for water, steam, gas, air, suction, oil and fire protection.

ROXBRO BRAIDED HOSE, which is furnished in continuous lengths up to 500 feet, is especially recommended for pneumatic use.

Cotton Hose, rubber-lined, furnished in light and heavy single fabrics and medium and heavy jacket fabrics; for all kinds of fire protection equipment.

Unlined linen hose, American Underwriters; supplied in all sizes and lengths, for interior fire protection equipment. Approved by all insurance interests.

PACKINGS; sheet form, for flanges and joints; adapted for all conditions of service. Piston and valve rod packings, round, square and spiral; for hot and cold water and hydraulic purposes.

GASKETS VALVES SPRINGS

RUBBER COVERED ROLLERS

New Rollers Complete. Rollers Re-covered.

High-grade coverings, made from selected gums; adapted for paper and textile mill uses, tanneries, tobacco factories, and every purpose for which rubber-covered rollers are used.

THE ROSSENDALE-REDDAWAY BELTING AND HOSE COMPANY

NEWARK, N. J., U. S. A.

"CAMEL HAIR" BELTING, CANVAS STITCHED BELTING, SOLID COTTON BELTING, ARABIAN "ASBESTOS BRAKE LINING"

"CAMEL" BRAND "CAMEL HAIR" BELTING

This belt is remarkable for its great strength (almost twice that of the leather belting), long lite, small slippage, minimum stretching, straight true running, and for the fact that it is less affected by dampness or acid fumes than any other kind of belting. This belting is also sold under a guarantee that it will give longer, better service than any other style of belting running under the same conditions. Made in four thicknesses as follows:

SINGLE "CAMEL" which corresponds to single leather or to 4-ply canvas and rubber.

MEDIUM "CAMEL" which corresponds to heavy single leather or to 5-ply canvas and rubber.

DOUBLE "CAMEL" which corresponds to double, and heavy double leather or to 6- to 8-ply rubber and canvas.

Extra heavy "Camel" to correspond to triple leather and all extra heavy types of belting.

STITCHED CANVAS BELTING "SPHINX BRAND"

Thoroughly equal to the best on the market in this type of belts, and affords economy if substituted as follows:

8-ply in place of double leather or 5 and 6-ply rubber.
6-ply in place of light double leather or 5-ply rubber.
4-ply in place of single leather or 3-ply rubber.
10-ply where extraordinary strength is required.

Made in all weights.

"BLACK-BIRD" WOVEN COTTON BELTING

FOR TRANSMISSION AND CONVEYOR WORK

An improved woven belt manufactured under high tension from the finest quality of long-staple cotton.

Impregnated with a special composition which protects the fibre, keeps the belt pliable, and prevents it from becoming hard and dry.

Will run well in steamy or wet places and on drives exposed to the weather.

ARABIAN "ASBESTOS BRAKE LINING"

Especially suitable for automobile brakes. Made in all widths from one to four inches. Standard thicknesses $\frac{3}{16}''$ and $\frac{1}{4}''$.

JEWELL BELTING COMPANY

Established 1848

Main Office, Belt Factory and Gem Leather Tannery

HARTFORD, CONN.

Oak Leather Tannery, Rome, Ga. Western Branch, 167 W. Lake St., Chicago

LEATHER BELTING AND LACING

Our Tannery is located in the heart of the best Oak Bark producing section of the country. Our hides are all selected for the sole purpose of making them into Belting leather. Our plants are equipped with the most modern up-to-date machinery and appliances; especially adapted to the production of high-grade leather and belting at a minimum cost. We make a grade of belt suitable for any class of work from the heaviest to the lightest. Our grades follow:

JEWELL SPECIAL PLANER BELT

Made from center cuts of specially selected heaviest oak bark tanned hides; leather specially treated for the work it has to do; perfectly balanced; has a maximum of strength and a minimum of stretch and is fully guaranteed.

JEWELL EXTRA BELT

Made of center cuts of heavy oak tanned belting butts from which all shoulder and flank stock has been removed; guaranteed to weigh an average of not less than 16 ounces to the square foot; especially recommended for heavy duty and slow speeds.

JEWELL HARTFORD BELT

Made of the same kind and quality of leather as the Jewell Extra, like it in all respects except thickness or weight; guaranteed to weigh an average of not less than 14 ounces to the square foot; especially recommended for small pulleys and high speeds.

JEWELL DYNAMO BELT

Always made in doubles from specially selected pliable oak tanned leather; perfectly balanced and constructed with special reference to the work it would have to do on electrical and other machinery having small pulleys running at high speeds.

All the above grades are fully guaranteed as to every detail of material and workmanship. All are put together with waterproof cement and oil dressed at special prices upon special request.

JEWELL DIVER BELT

Made of the very best selected heavy oak tanned leather, put together with waterproof cement and heavily oil dressed; specially recommended for heavy duty and where there is more or less dampness and steam.

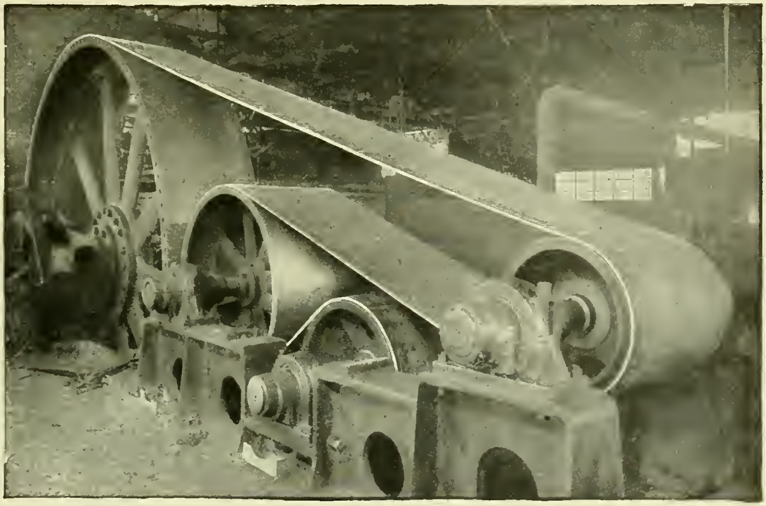
JEWELL ROUND BELTING

We are the largest manufacturers of Round Belting in the world. It is used on sewing machines and all other machinery where a grooved pulley is required; for bell and register cord in street cars. Our production is over ten million feet annually. It is made in all sizes from $\frac{1}{8}$ inch to $\frac{7}{16}$ inch.

JEWELL BELTING COMPANY

JEWELL GEM LEATHER

Undoubtedly the most remarkable leather product of the Twentieth Centurn; tanned by a special process which produces a leather that isn't injured by the action of hot or cold water, steam, oil, gas and many acids.



48-in. 3-ply Gem Belt transmitting up to 1900 horse power, at plant of Atlanta Steel Co., Atlanta, Ga. This Belt has already lasted more than 50 per cent. longer than the best oak tanned belt ever used on this drive before.

JEWELL GEM BELT

The Gem leather put together with a waterproof cement making a belt that is not affected by steam, gas, water, etc., as above stated, and in addition a belt that has the greatest possible pliability combined with the greatest tensile strength and the least tendency to stretch. It will slip less on the pulleys, transmit more power per inch of width with less loss of power than any belt known. The illustration herewith is a fair sample of what it will do.

GEM BELT LACING

Made both in sides and cut lace; the strongest and most economical Belt Lacing known.

OTHER JEWELL PRODUCTS

Other Jewell products are Agricultural Belting, Binder Straps, Trunk Straps, Skate Straps, Fan Belts, Automobile Leathers such as Brake Bands, Clutch Facings, Straps, etc., Polishing Leathers, and

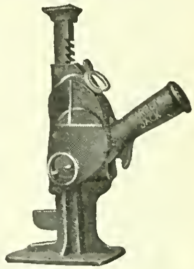
POTTER'S PATENT BELT HOOKS

THE DUFF MANUFACTURING CO.

N. S. PITTSBURG, PA., U. S. A.

GENUINE BARRETT JACKS; DUFF BALL-BEARING SCREW JACKS; DUFF-BETHLEHEM FORGED STEEL HYDRAULIC JACKS; GEARED RATCHET LEVER JACKS; AUTOMOBILE JACKS; TELESCOPE SCREW JACKS; OIL WELL JACKS; PIPE FORCING JACKS; MOTOR ARMATURE LIFTS, ETC.

BARRETT TRACK AND AUTOMATIC LOWERING JACKS.

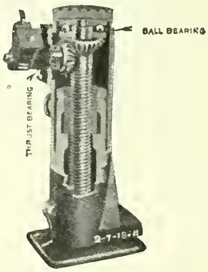


are made both single and double acting, in every type and size—for every purpose, ranging in capacity from ¾ to 20 tons.

They are quick acting, positive and durable, and will operate on continuous work at low maintenance cost.

They comprise the most popular line of lifting jacks in the world and are recognized as the standard by all leading railroads.

DUFF BALL-BEARING GEARED SCREW JACKS.



Sectional View

Are constructed of refined malleable iron and steel. All gears are of high carbon steel, drop forged, and have machine-cut teeth.

The load is carried on a large ball bearing of special design, reducing friction to an absolute minimum. The thrust on the bevel pinion is taken by another anti-friction bearing, an exclusive feature. Made in all sizes and capacities ranging from 10 tons to 75 tons.

THE DUFF-BETHLEHEM FORGED STEEL HYDRAULIC JACKS


Sectional View

Forged entirely out of steel—the latest and highest development in Hydraulic Jacks, they are more powerful, yet from 30 to 60% lighter than any other Hydraulic Jacks.

The design embodies no joints, few packings and but a third the number of parts of other jacks of similar type.

These jacks cause no trouble, are used at any angle, and operate at low cost under continuous service.

Made in 101 sizes and capacities, ranging from 10 to 500 tons.

COMPLETE INFORMATION.

Concerning the above and other types of lifting jacks may be secured by addressing this company.

THE RAIL JOINT COMPANY

GENERAL OFFICES:

185 MADISON AVENUE, - NEW YORK CITY

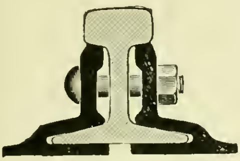
Catalog at Agencies

Boston, Mass. Pittsburg, Pa.
Chicago, Ill. Portland, Oregon
Denver, Colo. St. Louis, Mo.
Troy, N. Y.

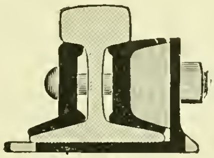
London, E C., Eng. Montreal, Can.

MAKERS OF BASE-SUPPORTED RAIL JOINTS FOR STANDARD AND SPECIAL RAIL SECTIONS, ALSO GIRDER, STEP OR COMPROMISE, FROG AND SWITCH, AND INSULATED RAIL JOINTS, PROTECTED BY PATENTS.

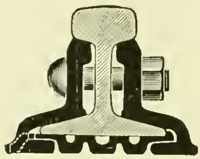
Highest Awards—Paris, 1900; Buffalo, 1901; St. Louis, 1904.



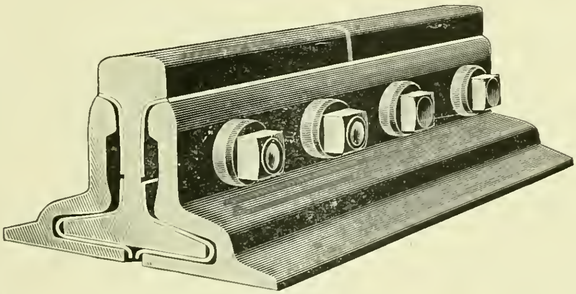
Continuous Joint



Weber Joint

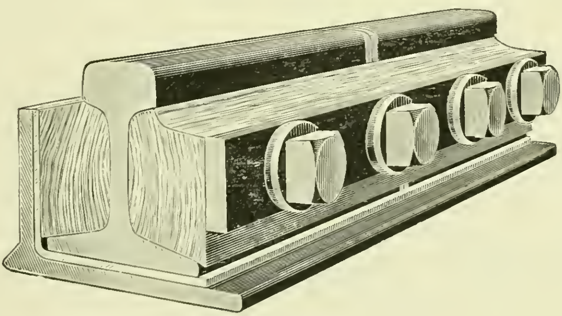


Wolhaupter Joint



Over 50,000 miles in use

Continuous Insulated Joint



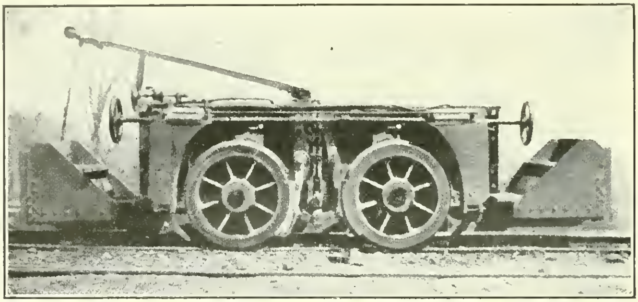
Rolled from Best Quality Steel

Weber Insulated Joint

MORGAN-GARDNER ELECTRIC CO.

CHICAGO, ILLINOIS

ELECTRIC MINE LOCOMOTIVES; ELECTRIC COAL CUTTING MACHINES; ELECTRIC DRILLS.



Mine Locomotive; 5 tons to 25 tons weight; 250 and 500 volts, 50 to 250 Horsepower.

We build all standard sizes, from 50 to 250 H.P., and weights from 5 to 25 tons. They are double armature type with four (4) driving wheels and flexible base. This flexibility makes it possible for the wheels to follow the rails on very narrow or uneven tracks.

The main frame is made all in one piece and closed across the bottom, which prevents the dirt and mud from getting up into the working parts. The frame also comes all inside between the drive wheels, which allows it to run in entries with small space outside of the rails, where an outside framed Locomotive could not be used.

The frame at each end is higher than at the sides, so as to protect the motorman in case of an accident. The Motors are of the multipolar type with internal fields, and completely closed in, except small opening at Commutator, which is protected by a cover, thus avoiding any danger of slate, or any substance from falling into the Armatures.

All gears are made from cast or hammered steel, and can be removed without taking the Locomotive apart. The Locomotive is provided with controlling lever, reverse lever, sand box levers, brake levers and electric headlight on both ends. The brakes will hold the wheels dead on sanded track.

The Drive Wheels have iron centers with rolled steel tires.

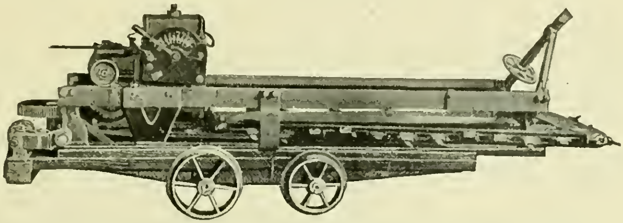
The controller is of best magnetic blowout construction, thoroughly insulated throughout, entirely waterproof, and guaranteed under full current to show rise not over fifty degrees above normal temperature. Large number now in use. Send for testimonials and prices. Special sizes and designs furnished. Full guarantee with each Motor.

TYPES AND RATING DATA MORGAN-GARDNER STANDARD MINE LOCOMOTIVES.

Type	Weight	Gauge		Wheel Base	Height to Top of Motor Inches	Height over All Rods, Etc. Inches	Length of Motor Inches	Length with Bumpers Inches	Diam. of Drivers Inches	Draw Bar Pull	Speed in M. P. H.	Approximate K. W.	No. of Inches to be added to G. for Total Width
		Max. Inches	Min. Inches										
R S	5	60	24	39 1/2	36 1/8	43 1/8	108	124	26	2500	7	37	7
R	6	60	32	39 1/2	36 1/8	43 1/8	141 1/4	157 1/4	26	3000	7	38	8 1/2
F	7 1/2	60	34	42 1/2	37 3/8	44 3/8	148	164	28	3750	7	55	8 1/2
F	8	60	34	42 1/2	37 3/8	44 3/8	148	164	28	4000	7	56	8 1/2
M	10	60	36	48	42 3/8	49 3/8	158	174	30	5000	8	74	9
M	12	60	36	48	42 3/8	49 3/8	158	174	30	6000	8	76	9
N	15	60	36	48	42 7/8	49 7/8	170	186	31	7500	8	111	9
N	17	60	36	48	42 7/8	49 7/8	170	186	31	8500	8	115	9

MORGAN-GARDNER ELECTRIC CO.

COAL CUTTING MACHINES.



Side view H. H. D. Machine. Undercut 5, 6 and 7 Feet.
Equipped with "Keystone" Chain and Self-propelling Truck. Wheels differentiated 2 inches in diameter to facilitate loading and unloading.

This machine weighs 2900 lbs., and is speeded to run in the full depth in 4½ minutes and back in 45 seconds. This speed can be increased to 3½ minutes, and 30 seconds backing out, according to quality of coal.

Total length of the six-foot cutting machine over all is ten feet. Height is 29 inches over all. Width across the machine at cutter head is 42 inches over the chain, and 45 inches over the bits, thus giving full 42-inch cut and allowing lap into previous cuts. The width across the frame is 24 inches; this enables the machine to be loaded on truck that will run on 28-inch gauge of track without making special truck—and still less gauge by making special truck.

The motor is of the Multipolar type with internal poles; this type of motor is very compact and accessible.

The armature is of the toothed gramme ring type, with the coils wound in slots below the surface of the armature, thus protecting them from danger by rough usage. The field coils are wound on spools that slip over the pole pieces and can readily be removed.

The gears are all made from steel with teeth cut out of the solid. The fact that our armatures run vertically does away with the bevel gears and greatly simplifies the gearing; all gears are of the plain spur type, and only one worm wheel.

We use the least number of gears or shafts in this machine that are known to be in any chain machine made at the present time. The chain is of the up-down-and-center link style, with all the bits straight and of the same length, which saves time in dressing and replacing.

Our machines are so constructed that both machine runner and helper can work at putting in bits at the same time. There are 48 bits in chain of six-foot undercut. The materials used in construction are cast and wrought steel throughout.

We use the least amperes of current per width of cut of any machine built. We use automatic throwout, both in front and back; this enables the machine to make full length cuts without danger of breaking anything. Our break washer, or safety washer, adds great security against accidental breaking.

Speed of travel of chain is 273 feet per minute. Revolutions of armature per minute is 750. The Horse Power necessary to operate this machine varies from 10 to 30, according to the character of the coal or substance to be cut. Our holding device is a model of perfection. These machines are offered strictly upon their merits, and we invite the most careful and critical examinations and tests. We build them for 250 or 500 volts. Plain or self-propelling, wood or steel trucks.

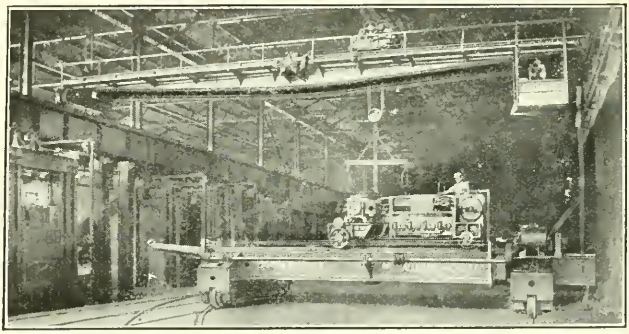
"Keystone" Chain showing Steel "Pick" Point Bits.

THE ALLIANCE MACHINE CO.

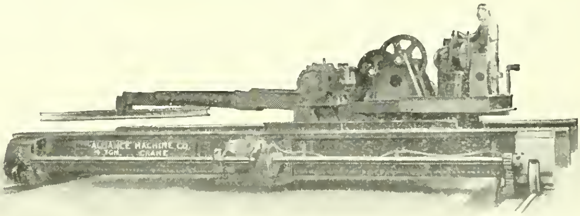
ENGINEERS AND BUILDERS

ALLIANCE OHIO

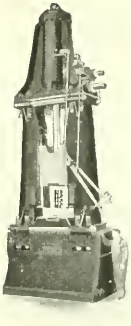
STANDARD ELECTRIC CRANES, ELECTRIC STRIPPING CRANES, ELECTRIC SOAKING PIT CRANES, ELECTRIC LADLE CRANES, ELECTRIC BUCKET CRANES, ELECTRIC CHARGING MACHINES, I-BEAM HOISTS, ORE BRIDGES, ROLLING MILL AND HYDRAULIC MACHINERY, SCALE CARS AND CHARGING LARRIES, COPPER CONVERTING MACHINERY, STEAM HAMMERS, HEAVY PUNCHES AND SHEARS, COKE PLANT MACHINERY.



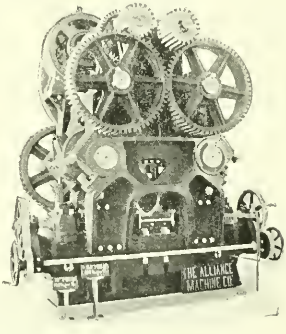
Open Hearth Charging Machine and Standard Overhead Traveling Crane



Billet Charging Machine. Floor Type

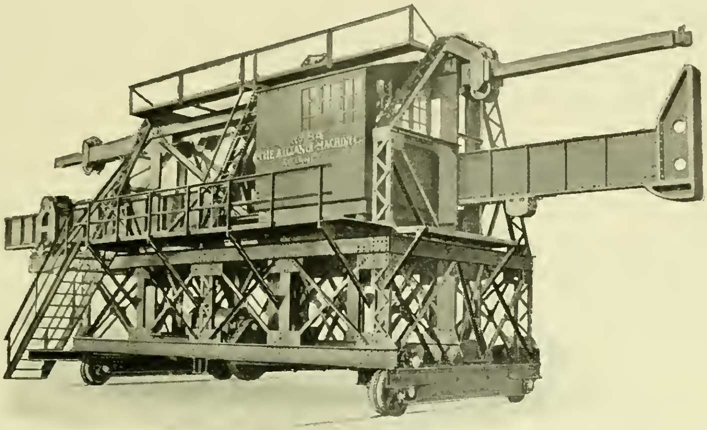


12000 lb. Steam Drop Hammer



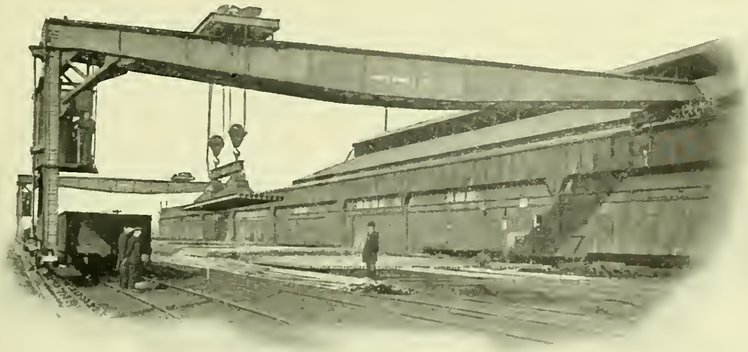
24″ Electric I-Beam Shear

THE ALLIANCE MACHINE CO.



ELECTRIC COKE PUSHER AND LEVELER

The above cut illustrates the latest type of combined coke pusher and leveler. All our pushers are of the all steel construction as this is absolutely necessary for the hard service to which coke pushers are subjected. We build various types of pushers to suit all kinds of ovens. We also build hoists, larries, cars and other machinery required in By-Product Coke Plants.



MAGNET GANTRY CRANE FOR HANDLING RAILS

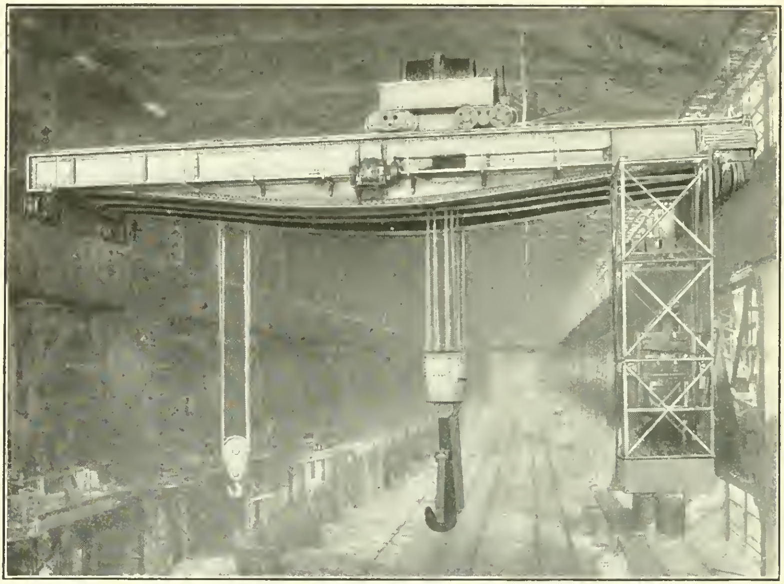
The above cut shows a single leg gantry crane equipped with special magnet for loading and unloading rails. The first day the above cranes were put in service at the plant of the Maryland Steel Company one of them unloaded a car of light rails in five minutes.

A traveling crane equipped with a magnet is absolutely the most economical way to handle material in bulk in stock yards or loading or unloading. The crane may be either standard traveling crane, single or double leg gantry or cantilever gantry, depending upon the conditions existing, and we will be glad to recommend the most suitable type.

Continued on next page

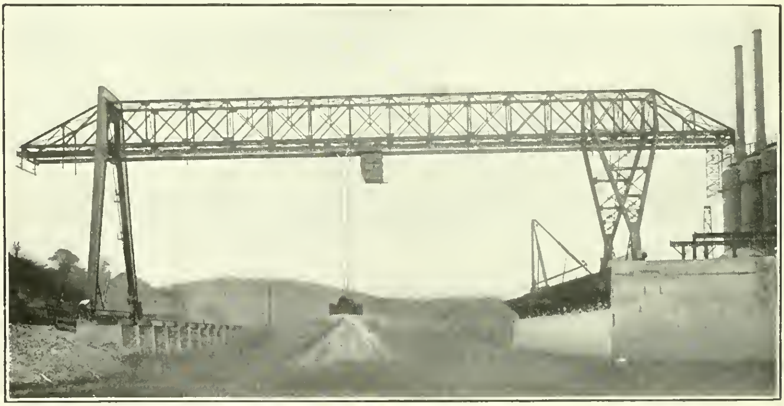
THE ALLIANCE MACHINE CO.

Continued from preceding page



150-TON SEVEN MOTOR FOUR GIRDER LADLE CRANE

These ladle cranes embody distinctly new features, being provided with four separate girders secured to steel end carriages, the outer pair of girders carries the main trolley and the inner pair of girders carries the auxiliary trolley, thus permitting both trolleys to be mounted on the center of their respective girders and also allowing the hoisting ropes to descend inside the base of support of the main trolley. The crane is fully described in our general catalog.



SIX-TON ORE BRIDGE

Our Ore Bridges are designed along our standard gantry crane lines and are equipped with man trolleys. Trolleys are provided with two drums driven by independent motors for handling the grab bucket. Squaring shafts across the bridge for the purpose of keeping it at all times square on the runway.

THE BROWN HOISTING MACHINERY COMPANY

CLEVELAND, OHIO

New York: 50 Church St. | Pittsburgh: Frick Bldg.
Chicago: Commercial National Bank Bldg. | San Francisco: Monadnock Bldg.

Manufacturers of

BROWNHOIST EQUIPMENT

COAL AND ORE HANDLING MACHINERY—Bridge tramways, fast plants, cantilever cranes, gantry cranes, furnace hoists, larries, transfer cars, bins, car tipples, and pig iron breakers. These machines are designed for the rapid handling of material and a long service. They are installed in many parts of the world.

LOCOMOTIVE CRANES—Eight and four-wheel and for any gauge track; speediest locomotive crane built; equipped with M. C. B. couplers, standard trucks and fittings, steam brake, all steel gears; can be fitted with either block, any kind of bucket, magnet or piledriver, all interchangeable in a short time; easily operated; fitted with steam or electric power or with an internal combustion engine.

BUCKETS—Grab buckets, two and single rope; drag line buckets; contractors' clam shell buckets; slag buckets, and tubs. The designs of these buckets are such they get a full load each time and are under the control of the operator at all times. The best of material is used throughout, giving strength and durability to the spades, bearings, and digging edges.

TRAMRAIL SYSTEMS—These systems handle all the material overhead, reaching every floor in each building and as much yard space as desired. We install the systems complete using the well-known Brownhoist trolleys, which are recognized as the standard trolleys. Operated by electric or other power.

ELECTRIC HOISTS—DC and AC. Designed especially for a hard service at maximum rated capacity, and for safety. The load is suspended entirely from steel parts. All gears are enclosed in a cast iron casing which contains a large supply of oil. These hoists are made in various capacities.

FREIGHT HANDLING EQUIPMENT. This includes several different machines designed for handling the freight at a much reduced cost over the present methods. The freight is handled overhead from car to sorting platform, warehouse, wagon or other cars. It requires just a few men, eliminates confusion and costly mistakes, and increases the terminal capacity.

FERROINCLAVE. A patented corrugated sheet steel used as a reinforcement for concrete. It requires no forms during erection, and is easily laid by the workmen. It is used for concrete roofs, floors, bins, walls, partitions, silos, bridges, stairs, etc.

We also make overhead travelling cranes, work-car cranes, jib cranes, pillar cranes, bridge cranes, cableways, crabs, winches, transfer tables and water-closet shields.

Catalogs and prices furnished on request

BROWN PORTABLE ELEVATOR CO.

HEAD OFFICE: 10 SO. LA SALLE ST., CHICAGO, ILL.

Factories at North Chicago, Ill., and Portland Oregon.

MANUFACTURERS OF PORTABLE ELEVATORS AND PILING MACHINERY, PORTABLE SECTIONAL CONVEYORS, AND WAREHOUSE EQUIPMENT.

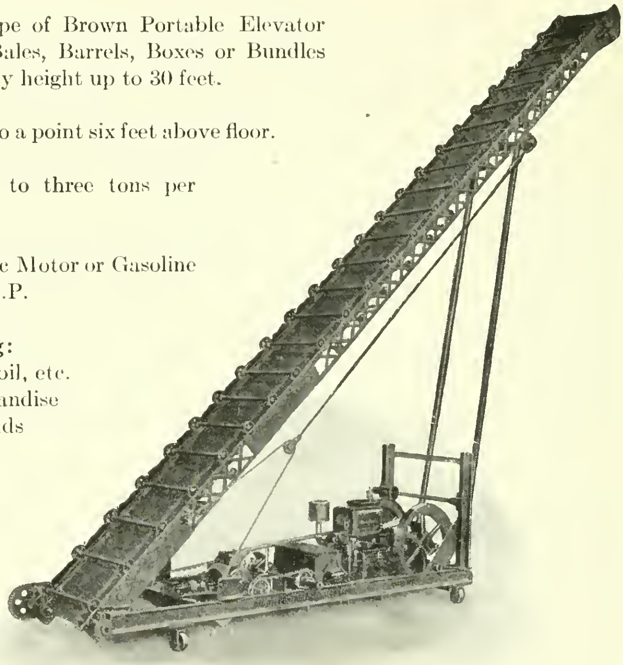
"Standard" type of Brown Portable Elevator for piling Bags, Bales, Barrels, Boxes or Bundles of any kind to any height up to 30 feet.

Carrier lowers to a point six feet above floor.

Capacity: One to three tons per minute.

Power: Electric Motor or Gasoline Engine ; 2 to 5 H.P.

In use for piling:
Barrels of sugar, oil, etc.
Boxes of merchandise
Bundles of all kinds
Kegs of nails
Rolls of wire
Bales of cotton, hay, straw, etc.
Sacks of grain, wool, sugar, fertilizer, etc.
Railway ties, shingles, etc., etc.



"Standard" Type Elevator, with Gasoline Engine

GENERAL DESCRIPTION

The Brown Portable Elevator or Tiering Machine consists of a *frame* of wood or all-steel construction, according to the desire of the purchaser or purpose for which the machine is to be used; an adjustable *carrier* over which runs an endless series of *carriages*, the whole mounted on easy running ball-bearing casters. All shafts turn in roller bearings.

The *frame* is well built to give the machine stability and to support the weight of the carrier with its load and the motive power.

Dimensions of "Standard" Type Elevators

Number	Elevates Height of	Floor Space	Approximate Weight.	
			Electric Power	Gasoline Power
0	12 ft.	82x31 ins.	900 lbs.	1400 lbs.
1	14 "	94x31 "	1000 "	1500 "
2	16 "	108x31 "	1100 "	1600 "
3	19 "	129x31 "	1400 "	1800 "
4	21 "	142x31 "	1500 "	2100 "
5	24 "	162x31 "	1800 "	2300 "
6	28 "	190x31 "	2000 "	2500 "
7	30 "	200x31 "	2100 "	2600 "

BROWN PORTABLE ELEVATOR CO.

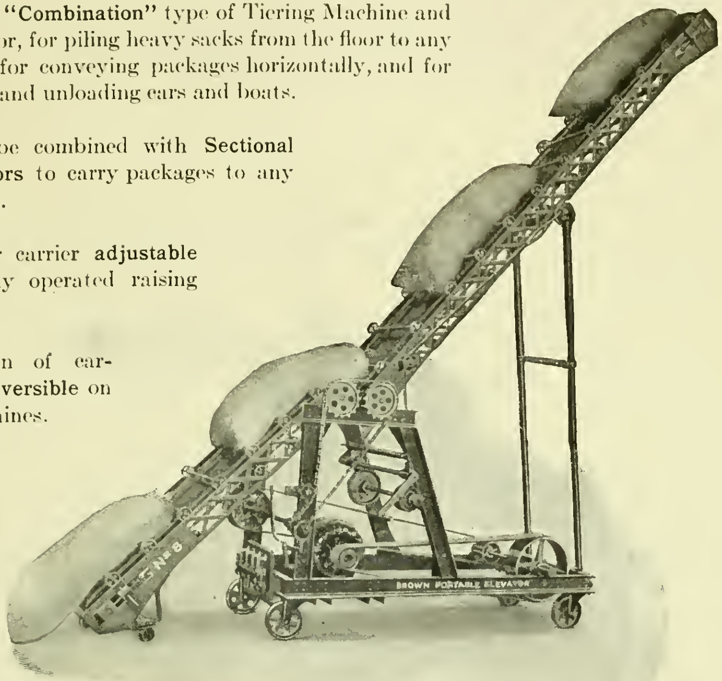
CHICAGO, ILL.

No. 8 **"Combination"** type of Tiering Machine and Conveyor, for piling heavy sacks from the floor to any height; for conveying packages horizontally, and for loading and unloading cars and boats.

Can be combined with **Sectional Conveyors** to carry packages to any distance.

Upper carrier **adjustable** by easily operated raising device.

Motion of carriages **reversible** on all machines.



"Combination" Type Elevator, with Electric Motor

The *carrier* is pivoted to the frame at its lower end, the upper end being supported and adjusted by an upright framework of iron piping or structural steel. This is connected by a steel cable on each side of the carrier to a (hand or power) raising device mounted on the frame, by which the carrier is raised as the pile increases in height. The carrying width is made to conform with the size of packages handled. The *carriages* are designed and spaced to provide suitable support for the various sizes, shapes and widths of packages.

In operation the packages are leaned against the foot of the carrier or placed on the carriages, which carry them to the top, where they are delivered, waist-high, to men standing on top of the pile, who place them in position.

The Brown Portable Elevator represents the highest development of mechanical efficiency in the handling of packed goods. Machines are made to meet any warehouse or mill conditions, and effect a saving of 50 to 80 per cent. of the cost of piling by hand. Lower as well as elevate; no complicated mechanism; prevent tearing or breaking of packages; easily moved by two men; reasonable in cost, and built for long service.

H. W. CALDWELL & SON COMPANY

CHICAGO, ILLINOIS

ELEVATING, CONVEYING AND POWER TRANSMITTING MACHINERY, MACHINE MOLDED AND PATTERN GEARS 1″ TO 6″ PITCH, CAST IRON SEMI-STEEL AND STEEL, LINK CHAIN BELTING, SPROCKET WHEELS, PULLEYS, FLY WHEELS, ROPE DRIVES, BEARINGS, COUPLINGS, FRICTION CLUTCHES, ETC.

Catalogue No. 34 contains complete lists

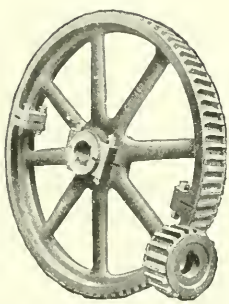
HELICOID CONVEYOR

Sole Manufacturers of "HELICOID CONVEYOR.
Made of one Continuous Strip of metal without lap or rivet.
Mounted on standard and extra heavy pipe or solid shaft.

LIST OF SIZES WITH DIMENSIONS

Standard Gauge Helicoid on regular size pipe

Diameter	Standard Lengths, Feet	Diameter of Couplings, Inches	Inside Diameter of Hollow Shaft, Inches	Outside Diameter of Hollow Shaft, Inches
3		$\frac{3}{4}$	1	$1\frac{5}{16}$
4	8	1	$1\frac{1}{4}$	$1\frac{5}{8}$
5	8	1	$1\frac{1}{4}$	$1\frac{5}{8}$
6	10	$1\frac{1}{2}$	$1\frac{3}{4}$	$2\frac{1}{8}$
7	10	$1\frac{1}{2}$	$1\frac{3}{4}$	$2\frac{1}{8}$
8	10	$1\frac{1}{2}$	2	$2\frac{3}{8}$
9	10	$1\frac{1}{2}$	2	$2\frac{3}{8}$
9 Sp'cl	10	2	$2\frac{1}{2}$	$2\frac{7}{8}$
10	10	$1\frac{1}{2}$	2	$2\frac{3}{8}$
12	12	2	$2\frac{1}{2}$	$2\frac{7}{8}$
12 Sp'cl	12	$2\frac{7}{16}$	3	$3\frac{1}{2}$
14	12	$2\frac{7}{16}$	3	$3\frac{1}{2}$
16	12	3	$3\frac{1}{2}$	4



GEARS

"CALDWELL-WALKER"

SPUR BEVEL

MITER MORTISE WHEELS

WORMS AND WORM WHEELS

1″ TO 6″ PITCH—CAST IRON—
SEMI-STEEL—STEEL—BRONZE

MACHINE MOLDED OR
MACHINE CUT TEETH

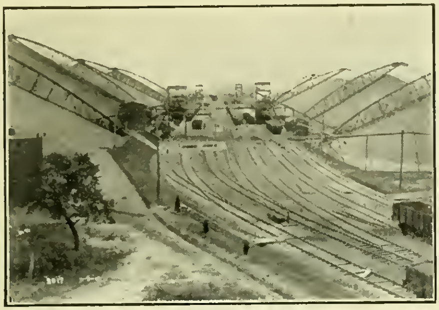
THE J. M. DODGE COMPANY

NICETOWN STA., P. & R. RAILWAY

PHILADELPHIA, PA.

THE DODGE SYSTEM OF STORING ANTHRACITE COAL, LONG RADIUS REVOLVING CRANES, BRIDGE TRAMWAYS, DIRECT UNLOADERS, SMITH BOX CAR LOADERS, COAL CHUTES, ENDLESS CABLE HAULS FOR RAILROAD CARS, TELPHERAGE, DESIGNERS AND BUILDERS OF LOCOMOTIVE COALING STATIONS AND RETAIL COAL POCKETS IN WOOD STEEL AND REINFORCED CONCRETE.

HANDLE COMPLETE CONTRACTS: FOUNDATIONS, BUILDINGS, AND MACHINERY



THE DODGE SYSTEM (Patented) OF STORING ANTHRACITE COAL

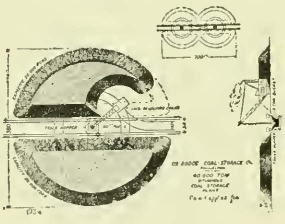
Capacity of piles from 15000 to 60000 tons. Two trimming machines and one reload-machine between piles constitute one group. Its effectiveness is due to simplicity of design, mechanical efficiency, minimum breakage, and low cost of handling.

BRIDGE TRAMWAYS AND DIRECT UNLOADERS

Complete installations of all types of Bridge Tramways and Direct Unloaders for high speed operation and maximum efficiency. Special attention given to the handling, storing and preparation of coal on docks.

LONG RADIUS REVOLVING CRANES FOR CIRCULAR STORAGE AND COALING STATIONS (PATENTED)

Suitable for storage capacities from 6000 to 40000 tons, and handling capacities from 40 to 200 tons per hour. This is the cheapest storage system for large bodies of bituminous coal or crushed stone, and combines low cost of handling with low investment cost. The crane can also be used for filling an elevated pocket for coaling locomotives, or for retail trade.



TELPHERAGE FOR FREIGHT HANDLING

Runs on top of mono-rail, permitting safest and simplest design of trolleys, combined with flexibility and smooth running at high speeds. Especially adapted for handling freight in railroad terminals and steamship piers. Special attention given to these problems.

HARDIE-TYNES MANUFACTURING CO.

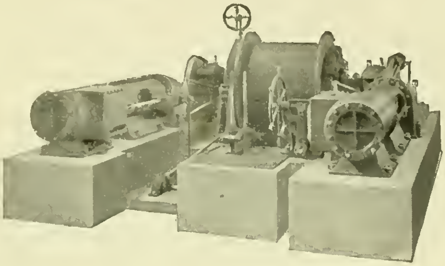
BIRMINGHAM, ALA.

HOISTING ENGINES, CORLISS ENGINES, AUTOMATIC ENGINES, SLIDE VALVE ENGINES, AIR COMPRESSORS, SPECIAL MACHINERY, HEAVY CASTINGS.

STEAM HOISTING ENGINES

First Motion Type

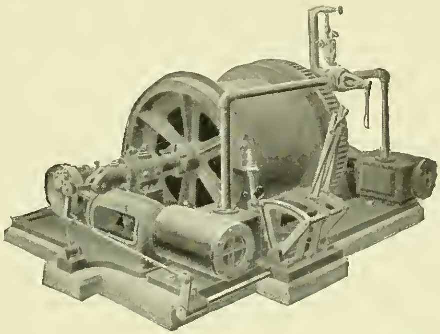
Built in all sizes up to and including 34x60 in. cylinders. Single or double drum. Band frictions. Link reverse. Steam auxiliaries or hand control.



STEAM HOISTING ENGINES

Geared Type

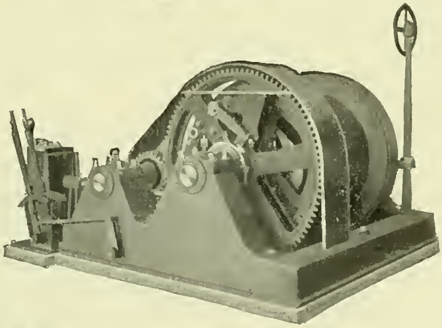
11x14 in. cylinders to 18x24 in. cylinders. Single or double drums. Band or "V" frictions. Link reverse. These Hoists, like our First Motion Machines, are built for hard and continuous service. The smaller sizes are excellent hoists for development operations.



ELECTRIC HOISTING ENGINES

Band Friction Type

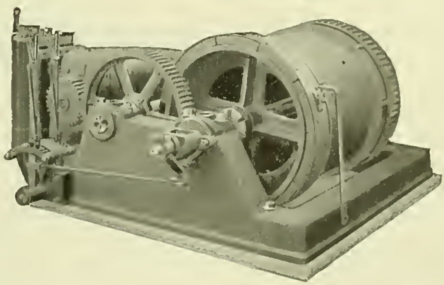
All sizes from 30 to 2,000 h.p. Single or double drums. Air operated auxiliaries or hand control. Built for heavy mining service.



ELECTRIC HOISTING ENGINES

"V" Friction Type

All sizes from 30 to 150 h.p. Single or double drums.

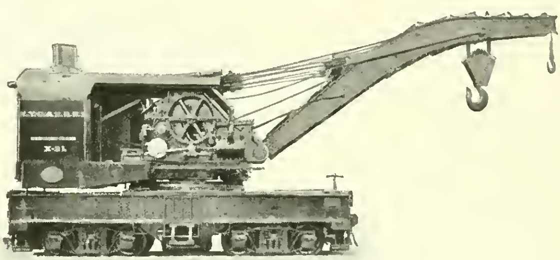


Engines for Endless Rope Haulage
Equipment for Gravity Tramways

INDUSTRIAL WORKS

BAY CITY, MICH.

WRECKING CRANES, LOCOMOTIVE CRANES, DRAG LINE EXCAVATORS, PILE DRIVERS, TRANSFER TABLES, PILLAR CRANES, HAND POWER DERRICKS, GRAB BUCKETS, LIFTING MAGNETS, ETC.

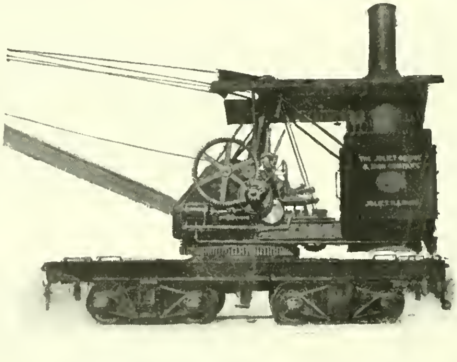


Wrecking Crane, capacity 120 tons at 17 ft. radius

Industrial Works cranes are built in all sizes from 1 to 150 tons capacity on the main hoist. Locomotive and Wrecking Cranes from 5 to 150 tons capacity may be self-propelling or non-propelling as desired. On this crane are three hoisting motions, main hoist, auxiliary hoist, and jib hoist. These are entirely independent of each other; are provided with independent brakes and operated by independent trains of cut steel gearing so that changes from one motion to the other are made with ease, and all parts are open and accessible.

In none of the three motions is any use made of ratchets for holding suspended loads, either during operation or during transfer from one motion to the other. These functions are performed by powerful brakes and self-locking worm wheels which enable the operator to use the motions with rapidity and safety.

Stability is provided by a system of telescopic out-riggers, all of which are self-contained within the car body.



Locomotive Crane for yard and road service

When desired any of our cranes may be equipped with an auxiliary drum and connections for operating a Grab Bucket; also complete equipment for operating Lifting Magnet.

Detailed specifications and full particulars furnished on application.

C. W. HUNT COMPANY

WEST NEW BRIGHTON, NEW YORK

HUNT STEEPLE TOWERS

are designed to be operated by one engineer. One engine is required for hoisting the steam shovel and another for running the trolley on the booms. Great speed makes these outfits especially suited to rapid unloading of vessels. The projecting booms are usually hinged to swing horizontally over the wharf. Where obstructions such as the rigging of vessels interfere, the booms can fold up in a vertical plane. Capacity of buckets ranges from ½ to 2½ tons.

Hunt Steeple Towers

HUNT TRANSPORTING BRIDGES

are adapted to the storage and reclaiming of coal over large areas. The one shown has a four-drum equalizing engine and operates with grab buckets at a capacity of 120 tons per hour. Furnished in capacities up to 600 tons per hour.

Hunt Transporting Bridges

INCLINED BOOM HOISTING ELEVATORS

are for rapid and economical hoisting of materials from vessels. The bucket, whether large or small, is carried from the hold of the vessel to the dumping place every trip in exactly the same course, and at any rapidity demanded. The bucket is carried exactly where wanted, rising vertically from the hold to the boom, running up the boom, and dumping at a fixed place.

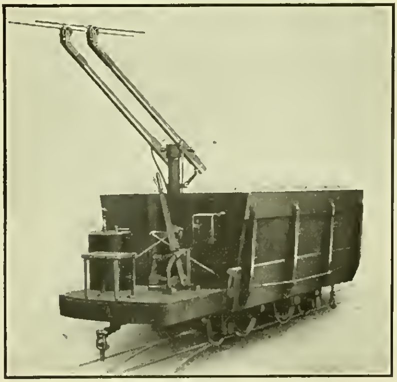
These elevators are proportioned to suit the work and for use either with tubs or grab buckets. The lighter size is especially adapted for coal or ore hoisting, using any size bucket up to one-ton capacity.

Inclined Boom Hoisting Elevators

HUNT MOTOR CARS
Self-Dumping

made in many types, capacities up to 10 tons, and are equipped with motors and overhead trolleys or shoes for third rail as desired. Suitable for transporting coal, fertilizer materials, ores, and other bulk materials.

Catalogs on request.



Hunt Motor Cars
Self-Dumping

THE LAMSON COMPANY

BOSTON, MASS., U. S. A.

PNEUMATIC TUBES—CASH, PARCEL, MESSAGE, AND MAIL CARRIERS; AUTOMATIC, SWEEP-OFF, PICKUP AND SELECTIVE CARRIERS; BELT CONVEYORS, TRAY CONVEYORS, SMALL LIFTS, ELEVATORS, ETC.

PNEUMATIC DESPATCH TUBES

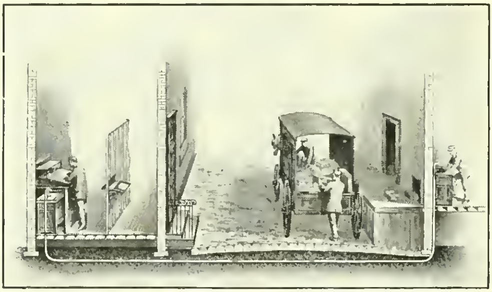
Designed and installed for all Office, Factory, Warehouse, Postal or Store Service requirements. Vacuum, Pressure, Vacuo-Pressure, Unit, "Two-way," Shifting Current or "Steam-jet" types in sizes of tubes ranging from $2\frac{1}{4}$ in. to 8 in. diameter. Latest Power-saving inventions. Over 50,000 stations of Lamson Tubes in use.

Desk Station 4" Mail Tubes in Private Office

FOOT POWER PNEUMATIC TUBES

No power plant required, operated by foot pressure. Efficient for lines up to 200 feet in length. Speaking tube attachments at small additional cost.

Sizes $2\frac{1}{4}$ and 3 inch O. D.



Carrying Documents Between Buildings

SELECTIVE CARRIERS

Entirely automatic—pick up a load at any point and deliver it at any desired station.

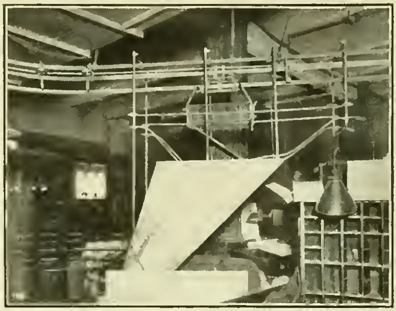
Made in any size to meet requirements–from carrying single sheets of paper to heavy bags of mail.

Automatic Mail Bag Carriers

THE LAMSON COMPANY

AUTOMATIC SWEEP-OFF AND DELIVERY CARRIERS

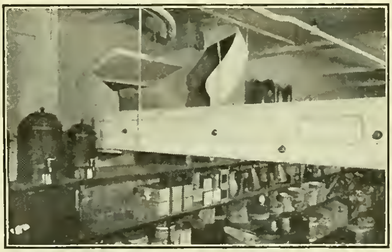
Constantly moving Baskets traveling on circuit lines and arranged to Sweep off Mail, Documents or Parcels from shelves and dump them into receiving chutes at required Receiving Stations. Made in Standard sizes as used by U. S. and Foreign Post Offices, or to Specifications.



Lamson Sweep-off and Dump Carriers for Post Office Work

LAMSON BELT AND TRAY CONVEYORS

All sizes for all conditions of Mail, Merchandise or Parcel Carrying. Special Conveyor Belts to carry Trays are built with Arresting Stations by which a constant supply of material is automatically maintained at each Station. Particular attention to complete Belt Conveyor Systems for assembly of "Delivery" and "Transfer" Parcels in large Department Stores.



Store Service Belt Conveyor and Chute Showing Self-closing Fire Door

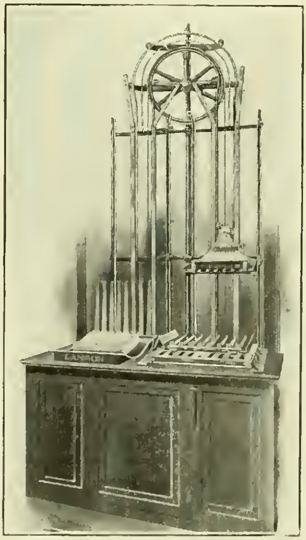
SPECIAL CONVEYORS

Made to meet any demand for assembly and distribution of Mail or Merchandise within or between buildings.

Plans and Estimates Free.

PICK-UP AND DELIVERY CARRIERS

Constantly moving metal "fingers" that noiselessly pick up documents or small articles from one tray or station and deliver them at another as desired. Made in standard sizes to meet special requirements.



Will pick up at any station and deliver at any other station

Representatives in all Principal Cities.

STEPHENS-ADAMSON MFG. CO.

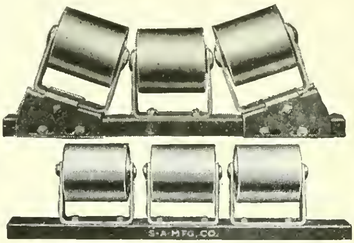
AURORA, ILLINOIS

CHICAGO, NEW YORK, PITTSBURG, PORTLAND, ST. LOUIS, SAN FRANCISCO, LOS ANGELES, BIRMINGHAM.

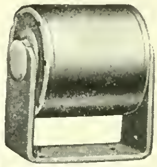
CONVEYING, SCREENING, AND TRANSMISSION MACHINERY

S-A BELT CONVEYORS

We are *primarily* conveying engineers, and our equipment is designed and manufactured to meet all special requirements. A most important feature of an economical conveyor system is the carrier. We present two types.



S-A Ball Bearing Unit Carriers



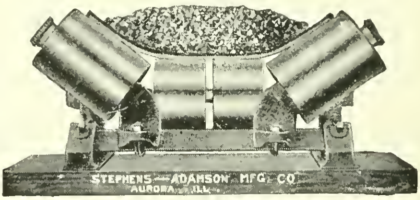
The Single Unit

THE "S-A" BALL BEARING UNIT CARRIER

This Unit Carrier has been developed to meet a consistent demand for an all steel ball bearing carrier with the obvious advantages of a carrier of this type. The single unit is the basis of its construction. Two, three, four or five of these Units may be combined to form a carrier of any width with the rolls arranged to suit any conditions. It is more easily adapted to different conditions than any carrier on the market. The troughers are adjustable to any angle and by means of additional units, the carrier may be easily and inexpensively enlarged to increase the capacity The Units may be carried in stock as repair parts, the same as elevator buckets, etc.

STYLE No. 9 CARRIER

This carrier has direct lubrication from grease cups to well-babbited bearings outside the conveyor belt. Thousands of these carriers have been manufactured and shipped to all parts of the world. Many miles of conveyors are operating on these carriers and hundreds of large conveyor users have adopted them as standard. The bearings are absolutely dustproof and wear for years. Their strength has been equal to all demands.



Style No. 9 Carrier

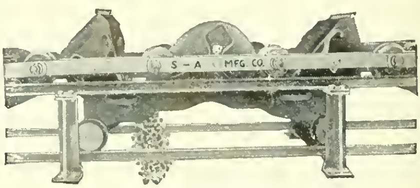
THE "S-A" IMPROVED PIVOTED BUCKET CARRIER

The Power Plant Conveyor

For handling coal and ashes in power plants, for handling cement clinker, etc.

No Spill. The lips of the buckets overlap perfectly, so that no particles of the material are spilled in transit.

Perfect Discharge. Each bucket turns completely over at the tripper, loosening sticky material and emptying the last particles of dust or grit.

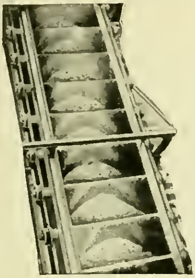


S-A Improved Pivoted Bucket Carrier

Malleable Iron Buckets. The buckets are not affected by temperature. Grit cannot wear the buckets or get into the bearings.

Perfect Alignment. The supporting shaft of each bucket passes thru both links of each chain and holds the chains in their proper upright position.

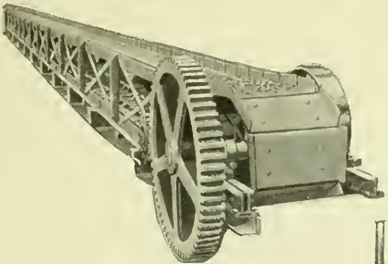
STEPHENS-ADAMSON MFG. CO.



72-inch "S-A" Jumbo Conveyor

GRAVEL WASHING AND ROCK CRUSHING EQUIPMENT

We have designed and equipped hundreds of these plants—commercially successful—in all parts of the country. The steel pan conveyor illustrated here, which is the largest ever built, is handling crushed stone in the plant of the Tomkins Cove Stone Company. It handles a capacity of 1,000 tons per hour up an incline of 45 degrees. The steel buckets are six feet in length and are supported by graphite-bushed self-lubricating steel rollers connected by double steel bar link chains. Many of our large conveyors of this type are in use throughout the country.



"S-A" Steel Pan Conveyor

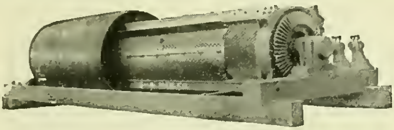
"S-A" STEEL PAN CONVEYORS

To meet the increasing demand for conveyors of large capacity and reliability, we build several types of steel pan conveyors. These conveyors are absolutely reliable and produce high conveying economy.

Protected Screw Take-ups

PROTECTED SCREW TAKE-UPS

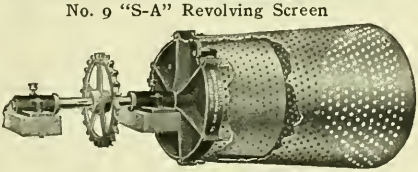
This style of take-up has a standard bearing mounted on a steel angle base. The angle protects the screw, brings the bearing lower and makes a more powerful and compact take-up than any other type.



No. 9 "S-A" Revolving Screen

"S-A" REVOLVING SCREENS

This type of revolving screen is designed for the severest crushing plant service. We also make many types of screens for lighter service.



"S-A" Improved Gilbert Screen

"S-A" IMPROVED GILBERT SCREEN

The standard screen for washing sand and gravel. The inner skirt takes the greatest wear and triples the life of the outer screen.

OUR MANUFACTURES AS ILLUSTRATED IN OUR GENERAL CATALOG INCLUDE THE FOLLOWING LINES

- **Bearings**
- **Belt Conveyors** for all applications
- **Brushes, Revolving,** for conveyors
- **Buckets, Elevator,** steel and malleable
- **Cars**
- **Car Hauls**
- **Car Pullers** and movers
- **Chains,** standard detachable, malleable and steel of all types
- **Clutches,** friction and jaw
- **Coal Handling Equipment** for pockets, power stations, washeries and tipples
- **Coal Crushers**
- **Conveyors,** belt, pan, chain for handling ore, coal, ashes, gravel, crushed rock, clay, cement, and all bulk or package products
- **Elevators,** chain and belt, for all applications
- **Feeders,** conveyor, apron, roll and shaking
- **Gates**
- **Gears**
- **Glass Works Conveyors**
- **Gravel Plant Equipment,** washing and screening
- **Hangers**
- **Pillow Blocks**
- **Pulleys**
- **Screens,** shaking and revolving for all applications
- **Sheaves**
- **Spouts**
- **Sprockets**
- **Transmission Systems and Equipment**

THE TRENTON IRON COMPANY

TRENTON, NEW JERSEY

MANUFACTURERS OF THE BLEICHERT SYSTEM OF AERIAL TRAMWAYS

The Bleichert System of Aerial Tramways is one whereby the material is carried in receptacles suspended from carriages running on stationary overhead cables in a continuous circuit, the loaded carriers along one cable and the empties returning along a lighter cable parallel with this, motion being imparted by means of a light endless traction rope to which the carriers are gripped.

No matter what the contour of the ground a Bleichert tramway will take the material in a bee line from where it is produced to where it is to be delivered without rehandling at a cost of 2 cents to 5 cents per ton a mile.

Angles may be made wherever it is necessary to change the direction of the line, but should be avoided wherever possible as adding to the first cost of the line and nearly always to the cost of operating.

Intermediate loading and discharge stations can be introduced at suitable locations if required, also intermediate brake or power stations according as power is developed or required, in cases where it is necessary to divide the line into sections.

No ground is too rugged for a bee line route; no grades too steep to surmount; no rivers or valleys too wide to cross; no grading, bridges or viaducts are required.

Structures are required to support the cables. These may be spaced varying distances apart according to the contour of the ground and structures are also required for applying tension to the track cables, wherever necessary in the longer lines to maintain their proper deflection. The supports may be of wood or of iron as preferred and are designed to correspond with the service and special condition of the location.

Fig. 1 Support in Bleichert Tramway

There is practically no limit to the length of a Bleichert Tramway. One line carries ore a distance of 21 miles. The loading terminal is 11,600 ft. above the discharge terminal and the capacity of the line is 40 tons per hour.

Spans occur in this line exceeding half a mile in the clear. Spans over 1000 ft. in any line are not unusual but the spacing of the supports under ordinary conditions will average 200 to 300 ft.

The track cables are of patented locked-coil construction (Fig. 2)

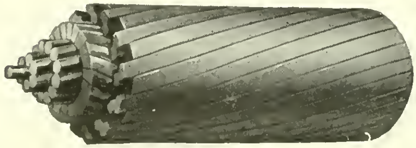


Fig. 2 Patent Locked Coil Track Cable

Fig. 3 Patent Coupling

THE BLEICHERT SYSTEM OF AERIAL TRAMWAYS

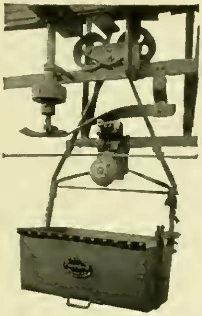


Fig. 4 Carrier with Webber Patent Compression Grip, showing patent automatic attacher

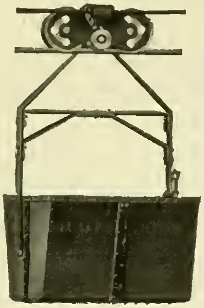


Fig. 5 Carrier with Bleichert Patent Automatic Overhead Grip

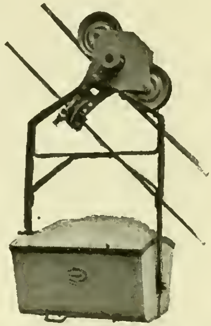


Fig. 6 Carrier with Bleichert Patent Automatic Underhung Grip

the smooth surface of which conduces toward a very uniform wear, which adds to the life of the cable and of the wheels that run on it.

These cables are made of a select grade of steel, in lengths varying from 500 to 1500 ft. which are joined by patented steel couplings illustrated in Fig. 3.

The grips for attaching the carriers to the traction rope are simple in construction, powerful, strong and efficient.

They are made for ropes running below or above the track cables according to the exigencies of the case, as shown in the cuts above. Fig. 4 represents the ordinary form of carrier with underhung grip suspended from a terminal rail, in the act of being mechanically attached to the traction rope. Fig. 5, a carrier with the Bleichert patent automatic overhead grip; and Fig. 6 a carrier with the Bleichert patent automatic underhung grip.

In the latter two the grips form an integral part of the carriage construction and operate in such a way that the weight of the carriers in any case acts as the gripping force in closing the jaws against the rope. These grips, therefore, are independent of any nice adjustment of the jaws and automatically accommodate themselves to irregularities of the rope which is a great advantage in long lines.

An overhead grip with positive operating mechanism is also made.

Well tried devices are provided for attaching and detaching the grips automatically at the terminals and other stations as may be required.

No buttons, lugs, or knots of any kind are required on the traction rope. This fact adds greatly to the life of the rope, since the wear is distributed uniformly over the entire rope and not confined to certain spots.

The same advantage pertains to these grips as compared to permanent connections of any kind. The ability to strip the line readily of its carriers when occasion occurs for resplicing the traction rope, or while making repairs is of itself a very great advantage.

Receptacles especially designed for any purpose are made of all kinds of materials. Buckets are most commonly used as shown in the illustration above, and these may be self-dumping if desired.

By cars especially designed to hold one or more buckets, the material may be transferred to and from surface tracks at the stations without rehandling.

Scales are furnished, if desired, specially designed for weighing the loaded carriers, or counters for automatically registering the number transported.

WELLER MANUFACTURING CO.

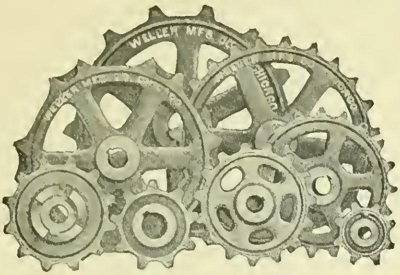
CHICAGO, ILLINOIS

ENGINEERS, FOUNDERS, MACHINISTS AND SHEET METAL WORKERS. MANUFACTURERS OF ELEVATING, CONVEYING AND POWER TRANSMITTING MACHINERY. COMPLETE GRAIN ELEVATOR EQUIPMENTS

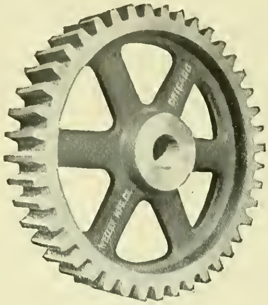
The complete catalog of the Weller Manufacturing Co., covering a complete line of elevating, conveying and power transmitting appliances, comprises a volume of more than 500 pages. We have endeavored to give in the following list, however, enough to indicate the range of their activities in these lines.

Angle plates for bevel and miter gears
Apron Conveyors
Barrel Elevators
Bearings, ring oiling, chain oiling, self oiling
Belt tighteners
Belting, Rubber, Canvas, Leather.
Blocks, Tackle
Buckets, Elevator
Cars, Steel Dump
Chain, Case hardened steel bushed, combination steel and malleable, detachable lock pintle, etc., etc.
Clutches, Friction, Square and Spiral Jaw
Collars
Conveyors, Belt, Spiral, Endless Chain
Couplings, Compression, Flanged face, Universal
Dump Cars
Elevator Appliances, including Buckets, Boots, heads, legging both steel and Wood, Power shovels, etc., etc.
Fans, for elevator heads, steel plate exhaust
Friction Clutches
Friction Hoists
Friction Wheels
Gears, Spur, Bevel, Cogs, Worm, etc.
Grease Cups
Hangers, Drop, Post
Hoists, American Safety rope, double drum, Moore anti-friction chain, single drum friction
Jack Screws, Locomotive
Link Belting and attachments
Manila Rope Transmission appliances
Oil Burners
Paper Frictions
Perforated Metal
Pillow Blocks
Pipe, plain riveted, spiral riveted
Power Shovels
Pulleys, cast iron, head, friction clutch, steel split, wood split, etc.
Shafting
Sheaves, manila rope transmission, wire rope transmission, wire rope hoisting
Sprocket Wheels
Spur Rack and Pinion
Take up Boxes
Tension Carriages
Trippers for Belt Conveyors
Winches, Hand and Power
Wire Cloth

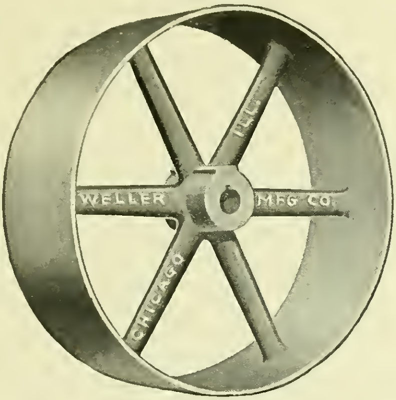
WELLER MANUFACTURING COMPANY



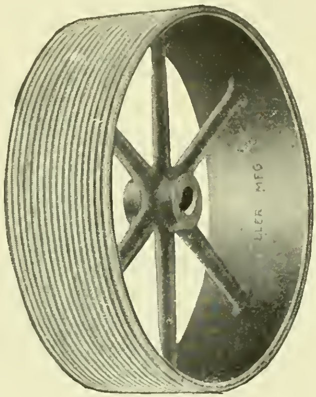
Sprockets



Gears

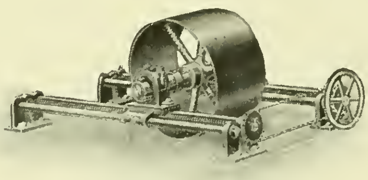


Pulleys

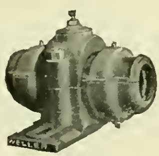


Sheaves

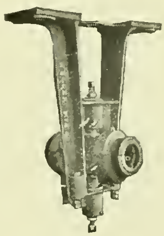
Dump Cars



Belt Tighteners



Pillow Blocks



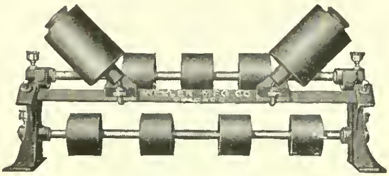
Hangers

See also next page

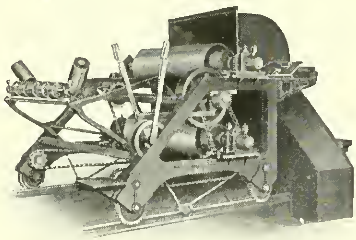
WELLER MANUFACTURING COMPANY

Continued from preceding pages

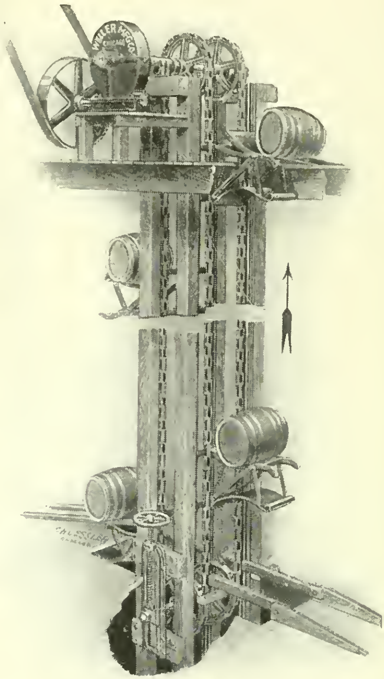
Spiral Screw Conveyor



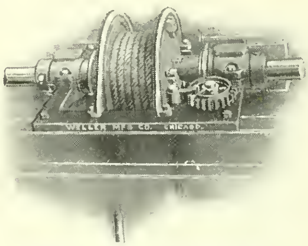
Belt Conveyor Troughing Rolls



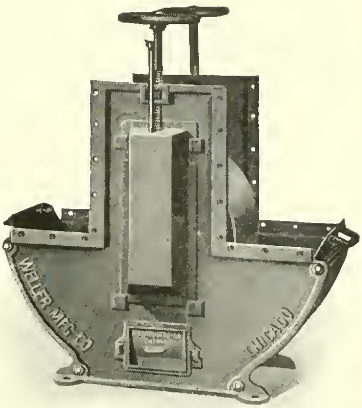
Trippers



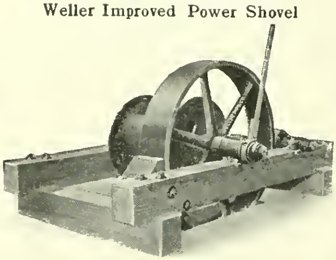
Barrel Elevator



Weller Improved Power Shovel



Standard C.I. Elevator Boot



Friction Hoist

VULCAN IRON WORKS

WILKES-BARRE, PA.

LOCOMOTIVES, HOISTING AND HAULAGE ENGINES, AIR COMPRESSORS, MINING AND CEMENT MACHINERY

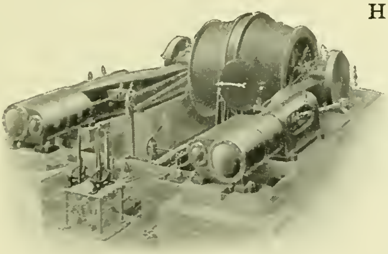
LOCOMOTIVES

Steam Locomotives. The Vulcan Iron Works make a specialty of, and have excellent facilities for, building locomotives to meet the needs of contractors, steel, mining, and industrial plants; and for plantation, logging, freight, switching and passenger service, in all styles and weights from seven to seventy tons on drivers. A separate and complete plant is devoted to this work.

We also endeavor to keep on hand full detail parts of standard types with a view of making deliveries on short notice. Our stock locomotives can be forwarded on receipt of lettering instructions.

Complete illustrated catalog on request.

Compressed Air Locomotives are adapted to general service in and around coal mines, or industrial plants where a fired locomotive would be dangerous. The dimensions, pressure and capacity of the tanks may be modified to suit special requirements and conditions. For very long runs a separate air tender can be provided, which may be attached or detached as desired. Detailed information on request.



HOISTING AND HAULAGE ENGINES

First Motion Hoists. These engines are built to the most rigid specifications for heavy hoisting work. The drums are of steel or iron, grooved and conical in shape so as to counterbalance the weight of the rope. The illustration shows a type used for shaft hoisting from 300 to 1000 ft. lifts fitted with steam reverse, steam brake, and the Nicholson Engine stop for the prevention of overwinding. Special catalog on request.

Geared Engines. Vulcan Geared Engines are used ordinarily where a hoisting speed of 800 ft. per minute or less is satisfactory, and for some purposes are preferred over First Motion Hoists because of the lesser first cost and of the smaller space occupied. These engines are simple and compact, but have ample proportions in all working parts so as to insure great durability and consequent low cost of maintenance. Special catalog on request.

Vulcan Electric Hoists. Vulcan Electric Hoists are built in standard sizes from 35 to 250 H.P. and with single or double drums. Special hoists will be designed to meet special conditions as may be required. If desired the equipment includes solenoid brakes and a device for the prevention of overwinding.

MACHINERY FOR THE MANUFACTURE OF PORTLAND CEMENT

We build Kilns for either the dry or wet process, and of any size to suit the needs or ideas of the customer. Although our specialty is rotary kilns, dryers and coolers, we also build engines, boilers, stacks, bins, sheet iron work of all kinds, conveying and elevating machinery, and other machinery used in or around the Modern Portland Cement Plant.

Catalog on request.

ALPHABETICAL INDEX TO CONDENSED CATALOGUES OF MECHANICAL EQUIPMENT

ALPHABETICAL INDEX TO DISPLAY ADVERTISEMENTS AND DIRECTORY CARDS

THE JOURNAL

of

THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS

AUGUST 1912

35 CENTS A COPY $3 A YEAR

ANNUAL MEETING: NEW YORK, DECEMBER 3-6

APPLICATIONS FOR MEMBERSHIP SHOULD BE FILED AT ONCE

Applications for membership must be filed by September 1 if they are to be acted upon at the Annual Meeting in December. As there is always delay during the summer in getting into touch with references, no time should be lost in forwarding names and answering letters when named as a reference.

COMMITTEE ON INCREASE OF MEMBERSHIP

I. E. Moultrop, *Chmn.*	W. T. Donnelly
C. W. Aiken	J. P. Ilsley
R. S. Allyn	E. B. Katte
R. M. Dixon	H. S. Wynkoop

AUGUST 1912 VOL 34 No. 8

THE JOURNAL
OF
THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS

PUBLICATION OFFICE, 29 WEST 39TH STREET . . . NEW YORK

CONTENTS

The Journal is published monthly by The American Society of Mechanical Engineers.
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THE JOURNAL

OF

THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS

VOL 34 AUGUST 1912 NUMBER 8

CURRENT AFFAIRS

Notwithstanding the general impression that work in the engineering societies has been suspended for the summer, activities are nevertheless to be seen in many lines. On July 1 the usual number of certificates of indebtedness, amounting to $6000, were retired according to agreement, certificates being drawn by lot by the Chairman of the Finance Committee. This will be done annually until the entire amount has been paid, unless the matter may be financed earlier through the enterprise of the members and thus permit the greater activities of the Society, which are meanwhile diminished by this necessity.

ENGINEERING CONGRESS IN 1915

At a meeting of the representatives of the four national engineering societies, the American Society of Civil Engineers, the American Institute of Mining Engineers, the American Society of Mechanical Engineers and the American Institute of Electrical Engineers, on June 11, it was tentatively agreed to recommend to these organizations and to the Society of Naval Architects and Marine Engineers that they, together with the members situated on the Pacific Coast, underwrite the expenses of the engineering congress projected for 1915. Prof. W. F. Durand

of Leland Stanford University, and George W. Dickie of San Francisco also attended the meeting as guests.

SUB-COMMITTEES ON THE INDUSTRIES

A joint meeting of all the sub-committees on the industries and of the Committee on Meetings, was called for Monday, July 29, to formulate the scope of the work. These sub-committees, as already announced, include Iron and Steel, Air Machinery, Railroad Equipment, Industrial Building, Hoisting and Conveying, and Fire Protection, and it is expected that there will be professional sessions upon several or all of these topics at the Annual Meeting in December, with papers and reports on their various phases.

COMMITTEE ON TOLERANCES IN SCREW THREAD FITS

The interest aroused in the subject of the measurement of taps, bolts and screws at the meeting of the Society in New York in March, has been crystallized by the appointment by the Council of a committee on permissible Tolerances in Screw Thread Fits, L. D. Burlingame, Chairman, Elwood Burdsall, F. G. Coburn, F. H. Colvin, A. A. Fuller, James Hartness, H. M. Leland, W. R. Porter and F. O. Wells, which will investigate this important matter and report to the Council at an early date.

VISIT OF WILLIAM CAWTHORNE UNWIN

The Society anticipates with much pleasure the visit of William Cawthorne Unwin to this country about September 1. Dr. Unwin, who was elected to Honorary Membership in the Society in 1898, and who is also an Honorary Member of the Institution of Mechanical Engineers of Great Britain, was formerly professor of engineering of the Royal School of Naval Architecture and Marine Engineering, of the Royal Engineering College, and of the City and Guilds Central Technical College, and is the author of a number of books on hydraulics and machine design.

Dr. Unwin is President this year of the Institution of Civil Engineers of Great Britain.

EIGHTIETH BIRTHDAY OF JOHN E. SWEET

In honor of the eightieth birthday of Prof. John E. Sweet, Honorary Member and Past-President of the Society, it is planned to tender a reception to Professor Sweet about the time of the Annual Meeting, and a committee of arrangements, consisting of Ambrose Swasey, Chairman, F. G. Tallman, Vice-

Chairman, F. A. Halsey, Treasurer, E. J. Armstrong, Secretary, E. N. Trump, and Calvin W. Rice, Secretary of the Society, ex-officio, is preparing for such an occasion. On July 8 this committee met in Syracuse, N. Y., and made tentative plans for an event which would suitably express the personal affection held by every friend for Professor Sweet, to whom more than to any other living member is due the organization of the Society. It is expected that this anniversary will be one of the most delightful occasions of the mid-winter meeting.

Calvin W. Rice, *Secretary*

MEDAL AWARDED TO GEORGE WESTINGHOUSE

George Westinghouse, Honorary Member and Past-President of the Society, was awarded the Edison Medal for "meritorious achievement in the development of the alternating-current system for light and power" at the annual banquet of the American Institute of Electrical Engineers in Boston on June 27. This medal, which was founded upon the initiative of the Edison Medal Association, comprising old associates of Thomas A. Edison, who subscribed a trust fund in 1901, is annually awarded by the Institute to that person in the United States or Canada performing the most meritorious achievement in electrical science, engineering, or electrical arts. It was designed by James Earle Frazer and bears on the obverse side a portrait of Thomas A. Edison, and on the reverse side an allegorical conception, the genius of electricity crowned by fame. The first award was made in 1909 to Elihu Thompson and the second in 1910 to Frank J. Sprague, the award to Mr. Westinghouse being the third. In accepting the medal Mr. Westinghouse gave an interesting sketch of the development of his inventions.

MEETING IN GERMANY

Plans for the meeting of the Society with the Verein deutscher Ingenieure in Leipzig, June 23-25, 1913, are already under way. The committee of arrangements appointed by the Council, consisting of Col. E. D. Meier, chairman, John W. Lieb, Jr., vice-chairman, Dr. W. F. M. Goss, Charles Whiting Baker, Major Wm. H. Wiley, and Dr. Alex. C. Humphreys, President, and Calvin W. Rice, Secretary, ex-officio, have opened negotiations with several steamship companies, and report that very reasonable figures can be obtained, despite the fact that the meeting is to be held during the height of the season, provided a sufficient number of members participate. By chartering an entire steamer demands varying from the most luxurious to the simplest and most economical can be adequately met. An early expression from members of the Society with regard to their intention to participate is greatly needed by the committee in order that further preparations may be made at once.

Letters received indicate the great interest felt by German engineers, manufacturers and officials in the proposed visit and more definite arrangements and further invitations from many cities and plants are contingent only upon the number and composition of our party. Besides Leipzig where the joint meeting takes place, many other points are on the alert to give the American engineers an opportunity to see the advances made in the profession and the growth of cordiality toward Americans generally, which is not confined to any one point. Places which it is tentatively proposed to visit are Hamburg, where there will be an opportunity to visit the greatest shipyards in Germany, Munich, with a reception by the Prince of Bavaria, Berlin, visiting the industrial plants, and by special arrangement the Castle of the Kaiser at Potsdam, Essen where there will be a reception by Krupp von Bohlen, Stuttgart, Düsseldorf, Cologne, Frankfort, Mannheim, and Heidelberg. In Leipzig it is also expected that there will be held during our visit a patriotic gathering in commemoration of the Battle of Leipzig, and it is expected that if the Kaiser is in the country at the time our party will be given a reception.

THE 1912 U. S. STANDARD

The American Society of Mechanical Engineers is a large factor in promoting the industrial progress of our country. This is usually accomplished by public spirited members serving on committees appointed for special tasks. The most recent development, recommended jointly by the Society and the National Association of Master Steam and Hot Water Fitters, is the Schedule of Standard Weight and Extra Heavy Flanged Fittings and Flanges known as "The 1912 U. S. Standard." This work has been performed on request and the changes have been made for engineering reasons. They refer particularly to heavy work and to the sizes above nine inches. The above being true, these changes would affect principally the large consumers of great responsibility where safety is essential and where no expense would be considered too great which would prevent accident and secure continuity of service.

The various makes of flanges and fittings now on the market, figured on the basis of the bolt stress, show a factor of safety in many cases as low as two and in a few cases even less. This compared with the necessary factor of safety of the pipe itself, which is approximately sixteen, shows at a glance the necessity for the changes made in The 1912 U. S. Standard, of bringing up the factor of safety in the bolts, flanges and fittings, especially in view of the enormous strains encountered due to changes of temperature.

The other important feature in The 1912 U. S. Standard is the uniformity of dimensions providing for interchangeability of fittings. Until very recently, each manufacturer had his own standard and chaos has resulted, so that the engineer must know what particular make is to be purchased before he can proceed to design or erect the piping work. Hereafter all fittings of all manufacturers who comply with the new schedule will be uniform in the principal dimensions, and this will be an important factor in obtaining quickly spare parts throughout the country and enable one readily to make repairs and alterations. The new standard does not attempt to fix the quality of the metal or the thickness of the shell of fittings, leaving this to

the manufacturers to regulate in accordance with their guarantee, depending on the pressure the fittings are to carry.

STANDARD WEIGHT FLANGES

In comparing The 1912 U. S. Schedule of Standard Weight Flanges with the alternative standard submitted by the sub-committee of manufacturers with respect to diameter of bolt circle, number of bolts and diameter of bolt holes, we find they are identical, with the one exception that The U. S. Standard gives $\frac{7}{8}$ in. instead of $\frac{3}{4}$ in. for diameter of bolt hole for 4-in. pipe.

The standard of the Engineering Standards Committee of Great Britain and the standard of the Verein deutscher Ingenieure do not have sizes exactly corresponding to the standard weight and extra heavy weight of The 1912 U. S. Standard, but have the most important dimensions, the same for all pressures, making their piping on low pressures unnecessarily heavy and expensive, but without securing absolute safety for high pressures. Comparing the proposed Manufacturers' Standard with (Table II) British standard pipe flanges for working steam pressures of 225 lb. per sq. in., we find the British standards give higher values, especially as far as number of bolts is concerned.

EXTRA HEAVY FLANGES

For extra heavy flanges up to 9 in. inclusive, The 1912 U. S Standard and the standard of most manufacturers are identical. Above 9 in. The U. S. Standard is somewhat larger than the present standards, as has been stated. With the British standard, the diameter of bolt circle and number of bolts are the same for pipes corresponding to The 1912 U. S. Standard or proposed Manufacturers' Standard weight and extra heavy weight, but from 10 in. on the diameter of the bolt circle is from $\frac{1}{4}$ to $\frac{1}{2}$ in. less than the proposed Manufacturers' Standard and $\frac{3}{4}$ in. less than The U. S. Standard. The number of bolts in most cases for pipes from 10 in. on in The U. S. 1912 and Manufacturers' is from two to four bolts greater than in the British standard. As far as size of bolts is concerned, the British standard makes a distinction between pipes for pressures up to 225 lb. and up to 325 lb. The bolts for pipes up to 225 lb. are below the Manufacturers' Standard $\frac{1}{8}$ in. in nearly every case and below the U. S. Standard from $\frac{1}{8}$ to $\frac{3}{8}$ in. In pipes for pressure of 325 lb. the British standard is the same as the proposed Manufacturers' schedule in all cases except 14 in. and 18 in. where

the British standard is $\frac{1}{8}$ in. larger than the Manufacturers' standard, but from $\frac{1}{8}$ to $\frac{1}{4}$ in. smaller than the U. S. standard.

It is thus seen that wherever there is a distinction between The 1912 U. S. and proposed Manufacturers' Standard, The 1912 U. S. Standard is invariably on the side of greater safety and strength and has the added feature of interchangeability where the proposed Manufacturers' schedule has different face to face dimensions. As to the comparison with the British and German standards it must be remembered that they cover by one standard both weights of the American specifications, and as would be naturally expected with compromises must have higher values for standard weight pipes and lower values for extra heavy weight pipes. However, in Germany there is reported in the public press dissatisfaction with the existing standards as not being safe. The Alsace Association of Owners of Steam Machinery prints in its annual report for 1911 as follows:

"It is nearly impossible to estimate with any degree of precision the bending stresses to which are submitted pipe flanges when, in order to obtain a good joint, the bolts are screwed tightly, especially if the flange has to withstand at the same time stresses due to expansion. As a result, many of the joints in pipes and similar apparatus are working with very low factors of safety, as has been shown lately by the fact that accidents from piping have been far more numerous than from boilers, and with as fatal consequences."

The 1912 U. S. Standard is the result of the efforts of the aforementioned committees covering a period of over a year during which time every detail was considered. The committee had the active coöperation of engineers representing large power plants, manufacturers and the U. S. Navy Department. Prominent engineers and architects throughout the country were communicated with and their opinions and advice received and considered, and the consummation is The 1912 U. S. Standard.

This standard has been in operation two months and has already been approved and adopted by the U. S. Navy Department, U. S. Bureau of Standards, Isthmian Canal Commission, and is under consideration by other departments of the U. S. Government. Large power concerns such as the Interboro Rapid Transit Company of New York, the New York Edison Company and others who in the past have had fittings made from their own patterns, because there was no standard, have agreed to adopt and use The 1912 U. S. Standard. Mr. L. B. Stillwell, electrical engineer of New York, has specified The 1912 U. S. Standard for fittings in the new

120,000 kilowatt power house now in process of construction at Hauto, Pa., by the Lehigh Navigation Electric Company. We are informed that manufacturers are beginning to fill orders and in some cases are preparing the dimensions in their own new catalogues in accordance with The 1912 U. S. Standard. The committee of The American Society of Mechanical Engineers have decided after the most careful consideration not to reopen the subject, as has been erroneously reported.

This schedule was published in the February 1912 Journal of The American Society of Mechanical Engineers and February 1912 Bulletin of the National Association of Master Steam and Hot Water Fitters, and copies may be had upon request from either the National Association of Master Steam and Hot Water Fitters or The American Society of Mechanical Engineers.

NECROLOGY

GEORGE R. BABBITT

George Rodney Babbitt, president and treasurer of the American Oil Company of Providence, R. I., died at his home in Edgewood, R. I., on June 29, 1912. Mr. Babbitt, who was born at Berkley, Bristol Co., Mass., on June 27, 1842, received his education in the schools of that locality and in Fall River, Mass. As a young man he followed the sea for several years, making a voyage to California in 1860, then a tedious undertaking.

In 1862 Mr. Babbitt came to Providence and entered the employ of the Burnside Rifle Works, becoming a sub-contractor on parts of the work. When the works closed down three years later to be refitted for building locomotives, he spent a period in the Pennsylvania oil fields, and the following year became associated with William A. Harris, the Harris-Corliss steam engine builder. With this concern he filled the positions of machinist, foreman and superintendent, and invented and patented several improvements, among them a piston packing, for which he received a medal at the Cincinnati Industrial Exposition in 1874, a releasing gear and an extended piston.

In October 1888, he was tendered the position of superintendent of the heavy ordnance department of the Government at Washington, D. C., which, however, he declined. He bought an interest in the American Oil Company of Providence in 1892, with which he was associated at the time of his death. He was frequently called upon to act as a consulting and mechanical engineer for large manufacturing concerns, both for new work and for the best methods of repairing. In 1894 he patented an automatic barrel filler.

One notable achievement of Mr. Babbitt's was his plan for floating the steamship Paris which had grounded on some rocks while crossing the Atlantic, and which he proposed to the owners after reading an illustrated newspaper description of the accident.

WILLIAM J. EDWARDS

William J. Edwards died at his home in Binghamton, N. Y., on April 21, 1912. Mr. Edwards, who was born in Albany on February 20, 1873, received his preparatory education at the Centenary Collegiate Institute at Hackettstown, N. J., and his technical training at Pratt Institute in Brooklyn. Upon his graduation in 1893 he entered the employ of the Tide Water Oil Company in Bayonne, N. J., where he became acting master mechanic of the company, with charge of the design and construction of the complete oil refinery, and later superintendent of the can and case department. He was also during his residence in Bayonne president of the Bayonne Castings Company, which made a specialty of monel metal castings.

In 1911 he removed to Binghamton, N. Y., to become vice-president and treasurer of the Binghamton Clothing Company, a position which he held at the time of his death.

LAWRENCE WHITCOMB

Lawrence Whitcomb, who died in Boston, Mass., on May 18, 1912, was born May 2, 1863, at Malden, Mass., and was educated in the Boston and Roxbury public schools. In 1881 he left school without completing his course and entered the shoe business, becoming a salesman and factory superintendent. In 1890 he joined the organization of the firm of Whitcomb, Wead & Company, real estate brokers and agents, which became one of the large real estate firms of Boston. Mr. Whitcomb was also interested in the development of the National Brake & Clutch Company and its successor the Cork Insert Company, which owned patents covering the use of cork for friction purposes in brake shoes, clutches, pulleys, etc., and finding that the use for these devices was very large he made a careful study of mechanical conditions and requirements and patented several new applications of his own. He was at the time of his death treasurer and general manager of this company.

THE REDUCTION IN TEMPERATURE OF CONDENSING WATER RESERVOIRS DUE TO COOLING EFFECTS OF AIR AND EVAPORATION

By W. B. Ruggles, Published in The Journal for April

ABSTRACT OF PAPER

The tests described in this paper were made to determine the heat radiation from a cooling reservoir of about $6\frac{1}{2}$ acres, at the Crescent Portland Cement Company's plant at Wampum, Pa. The amount of heat delivered to the reservoir from the engines and compressors was measured by hourly readings for power and vacuum and the reduction of temperature, due to pumping in fresh water from the Beaver River, and by rain was also taken. By frequent readings of temperature of tail water, intake water and air, the cooling effect of the air on a unit of surface of water per unit of difference of temperature was easily determined.

DISCUSSION

Forrest E. Cardullo. It may be shown from the kinetic theory of heat that the rate of evaporation from a water surface is approximately proportional to the difference between the saturation pressure of water vapor at the temperature of the water and the actual pressure of the water vapor in the air. Experiment shows that the rate of evaporation in still air, i. e., air in which the only currents are those caused by the temperature conditions and not by the wind, the rate of evaporation is approximately 3/10 lb. of water per sq. ft. of surface per hour for every pound difference in vapor pressure. When there is an appreciable amount of wind, the rate of evaporation becomes higher, and in case the wind is very brisk it may become four or five times as great as the value given. Furthermore, the rate of evaporation depends on the size and form of the pond, being

The American Society of Mechanical Engineers, 29 West 39th Street, New York. All discussion is subject to revision.

greater in the case of a small and narrow pond and less in the case of a large or circular pond, since the air which sweeps across the large pond will be partially saturated with moisture before it has gone very far.[1]

There is a reasonable concordance between theory and the actual results which Mr. Ruggles obtains. For the week ending May 7 the amount of heat carried away was about 15 per cent greater than theory would indicate. For the week ending July 12 it was a few per cent less, but for the week ending November 27 it was nearly twice as great.

This is not contrary to theory as it may seem to be since one very essential element has been omitted in the data of Mr. Ruggles' paper, namely the velocity and direction of the wind, and it is reasonable to assume that in November the amount of wind would be considerably greater than during May or July. The direction of the wind would also have a considerable effect, since a wind blowing the long way of the reservoir would produce a lower rate of evaporation than one which blew crosswise.

Mr. Ruggles gives for the average temperature of the reservoir the mean of the temperature of the intake and the condenser discharge. As a matter of fact, it could be but little higher than the temperature of the intake. He assumes that the steam rejected by the engines was of 100 per cent quality. The quality was probably not far from 85 per cent and might be as low as 80 per cent. His figures on the amount of heat delivered to the reservoir are therefore about 20 per cent too high.

An inspection of Mr. Ruggles' paper would lead one to expect that a cooling pond would dispose of 3½ b.t.u. per sq. ft. per hr. per deg. difference in temperature between the water in the pond and the air. When, however, the temperature of the condenser intake is taken for the temperature of the pond, and a quality of 84 per cent is assumed for the steam discharged to the condensers, the b.t.u. per sq. ft. per hr. per deg. difference in temperature ranges from 4.13 to 7.60, being higher in hot weather than in cold weather. This is as it should be, since the relative humidity is less and the vapor pressure difference and rate of evaporation are greater in hot weather.

The average rate of evaporation for the week is not the rate

[1] For the development of this theory and its application to the design of cooling ponds see Practical Thermodynamics, McGraw-Hill Book Co., pp. 264-267.

of evaporation which would be produced by the average conditions of temperature and humidity for the week. On this account, and because the weather cannot be predicted in advance, and on account of the great variations of weather conditions to be expected, it is foolish to attempt any degree of refinement in the design of cooling ponds. It is not desired to design a cooling pond which will give an intake temperature of 90 deg. at 2 o'clock in the afternoon on July 4, but to design one which will, when used in connection with the other apparatus of the station, give the required power output at a minimum total cost. Either the data given by Mr. Ruggles or the method mentioned in this discussion will enable one to do this.

Wm. T. Donnelly said he had discussed the elements of the subject with the author before the design of the reservoir and afterwards had discussed the results. It seemed to him that more depended upon the humidity of the air than upon any other single factor. The atmosphere must be considered as a condenser and the rate of flow of vapor into the atmosphere is affected very much by the condensation.

In the winter the greater evaporation is due to the relatively lower humidity of the air, and the passing off of the vapor from the warm surface is more rapid on that account. The author is to be commended for giving information along new lines dealing with manufacturing conditions as met with all over the country, and it is not necessary to have it to the third or fourth decimal place to make it useful.

Willis H. Carrier. As Professor Cardullo suggested, it would seem that the rate of heat transfer would be in direct proportion to the total heat difference in the air at the air temperature, and at a saturated air temperature, corresponding to the water temperature of the air in the pond. In other words, there is a certain amount of heat in the natural air to start with, which being in immediate contact with the pond is raised to and saturated at the temperature of the pond, so that the amount of heat taken away from the pond under the same conditions of wind would be in direct proportion to this total heat difference. This would naturally lead to the conclusion that there would be a much higher rate per degree difference at the high temperatures as the total heat of saturated air increases very rapidly at the

higher temperatures. But this is not so, and Professor Cardullo has offered an explanation why it is not. From an engineering standpoint it is very interesting to know that the rate of heat transfer is much greater in the months when the air is cooler and the temperature of the pond is lower, so that, as Professor Cardullo says, calculations may be made upon the summer conditions with very little wind.

There is also another point to be taken into account where there is no forced circulation, that is, that when the temperature increases, the rate of transmission would also be increased by the fact that the natural air currents produced by this temperature are increased, producing an induced circulation. Just what the effect of this is and what the laws governing it are is very difficult to determine, but probably they are very similar to those of direct radiation, which would give a greater rate of transfer at a greater temperature difference. This, however, does not seem to be of much interest from a practical standpoint. So many variables enter into the conditions that the approximate constants as shown by the results of these tests may be accepted as the average conditions.

Mr. Carrier believes that certain statements made by Mr. Donnelly with reference to the effect of the humidity upon the rate of heat transfer may be somewhat in error. It was stated that the greater heat transfer may be accounted for in cooler months by the lower relative humidity. The fact is that it is the reverse. The relative humidity according to all weather bureau readings is lower during the hotter months than during the spring and fall. There is a considerable higher relative, not absolute, humidity in the fall and spring. The question is rather one of wet-bulb temperature, which is the only temperature worth considering, because that is the measure of the total heat in the air, and it is the temperature at which water will arrive if subjected to the air for a sufficient time. The effect of the relative humidity, of the lower relative humidity, is one of a low wet-bulb temperature, and the amount of evaporation that occurs is measured by the difference between the water temperature and the wet-bulb temperature. The relative humidity plays but a small part in this.

The Author. There is no doubt, as Professor Cardullo states, that the direction and force of the wind have considerable influence on the amount of evaporation, but as these tests were made

in order to obtain some practical and reasonable basis for estimating the size of a reservoir required for any particular plant and not for a mere academic discussion of theories, the amount of wind was purposely omitted as introducing an uncertain factor which would be of no future use. Moreover the author considered the average of three different weeks widely separated would give a fair average of yearly conditions.

Professor Cardullo is mistaken regarding the average temperature of the pond being nearly the temperature of the intake, and the author cannot understand where he could get such information. Actual readings 100 ft. apart show the mean temperature, as he stated, to be the average between the tail water temperature and that of the intake water.

Presumably Professor Cardullo in referring to the quality of the steam being only about 80 per cent or 85 per cent meant the percentage of dryness and probably had in mind the steam as it left the low-pressure cylinders or as it entered the condenser. But as the amount of steam figured was that which entered the engine and was corrected by calorimeter test for moisture, and as all the heat, except that utilized for power, went into the condenser and reservoir and a very small percentage was due to radiation from the engine cylinders, his criticism of the tests in this respect is futile.

In making these tests the author had no idea that the results obtained would be absolute, but thought that they would throw light on a subject which as far as he was able to learn had not been treated before.

RESULTS OF TESTS ON THE DISCHARGE CAPACITY OF SAFETY VALVES

By E. F. Miller and A. B. Carhart, Published in The Journal for February

ABSTRACT OF PAPER

The paper gives the results of a series of tests made on the discharge capacity of 3-in. and 3½-in. locomotive pop safety valves at varying lifts under 200 lb. boiler pressure, also results of tests on the discharge capacity of 3-in. and 3½-in. inspector valves of the flat-seated and bevel-seated types under 100 and 150 lb. gage pressure. In all of the tests the steam was condensed in a surface condenser and the condensation weighed. The tests were run from 30 minutes to 1 hour in duration so that errors of weighing were reduced to a minimum. In all of the tests the valve was set a definite distance from its seat and held rigidly, the spring of the valve having been removed.

Results of the tests are given both in the form of a plot and numerically.

DISCUSSION

Chas. H. Chase. The records of these tests give an opportunity for the calculation of an average constant for comparison with the constant of Napier's equation and with the constant determined by a series of experiments which were described in a paper [1] presented before the Society in 1909.

That series of tests was made on 3-in., 3½-in., and 4-in. valves of the stationary type, and on 1½-in., 3-in. and 3½-in. locomotive type valves. The valve springs were removed and the lift of the valve disc was controlled in each test by a solid threaded spindle carried by the valve case. The discharge was found by weighing the feed-water, the water level being kept constant. The steam had an average superheat of 37.2 deg. fahr. All of the valves had 45 deg. bevel seats, and the discharge areas were found by the equation

$$a=2.22\times D\times l+1.11\times l^2$$

except in two of the 24 tests where the valve lift was greater than

[1] Safety Valve Capacity, P. G. Darling, Trans. Am. Soc. M. E., vol. 31, p. 109.

Presented at the Boston Meeting, March 16, and at the Spring Meeting, Cleveland, O., 1912, of The American Society of Mechanical Engineers.

the depth of seat and then the equation used was

$$a = 2.22 \times D \times d + 1.11 \times d^2 + D \times (l - d)$$

in which D = diameter of valve, l = valve lift, d = depth of valve seat.

The average constant for the tests was 47.5, to compare with

TABLE 4 VALUES OF CONSTANTS WITH LIFTS AND AREAS OF DISCHARGE

3-In. Regular Bevel Seat
Pressure 100 Lb. Gage

Lift	E	=	Constant	×	a	×	P
0.0207	806	=	50.8	×	0.1383	×	114.7
0.0507	2054	=	52.6	×	0.3405	×	114.7
0.0807	3264	=	52.1	×	0.5447	×	114.7
0.1007	4065	=	52.0	×	0.6819	×	114.7

3-In. Regular Bevel Seat
Pressure 150 Lb. Gage

Lift	E	=	Constant	×	a	×	P
0.021	1225	=	53.0	×	0.1403	×	164.7
0.051	2961	=	52.5	×	0.3425	×	164.7
0.081	4608	=	51.2	×	0.5467	×	164.7
0.1010	5743	=	51.0	×	0.6840	×	164.7

3½-In. Bevel Seat
Pressure 100 Lb. Gage

Lift	E	=	Constant	×	a	×	P
0.0215	972	=	50.6	×	0.1676	×	114.7
0.0515	2384	=	51.5	×	0.4031	×	114.7
0.0815	3810	=	51.9	×	0.6406	×	114.7
0.1015	4690	=	51.2	×	0.8001	×	114.7

3½-In. Bevel Seat
Pressure 150 Lb. Gage

Lift	E	=	Constant	×	a	×	P
0.0222	1484	=	52.1	×	0.1730	×	164.7
0.0522	3495	=	51.9	×	0.4086	×	164.7
0.0822	5454	=	51.2	×	0.6462	×	164.7
0.1022	6854	=	51.6	×	0.8057	×	164.7

the value 51.4 in Napier's equation

$$E = \text{constant} \times a \times P$$

for discharge in pounds per hour.

In the tests of 3-in. and $3\frac{1}{2}$-in. valves with bevel seats now under discussion, the lift was greater than the depth of valve seat at 0.08 and 0.10 in. However, as a perpendicular from the lower angle

of the valve disc does not clear the seat in either case, there remains a discharge orifice bounded by two parallel conical surfaces as on the lower lifts, and the same method of calculation for discharge area may be used.

Table 4 gives the values of the constants together with the lifts and areas of discharge. Here the average value of the constant is 51.7.

If the calculation of discharge areas for lifts greater than the depth of valve seat is made in the same way as in the tests quoted, the average value of all the constants becomes 49.0. That method is, however, inadmissible for the reason given in Par. 4 of this discussion and we are brought to the conclusion from these tests that for lifts up to 0.10 in. the discharge of dry steam for valves with

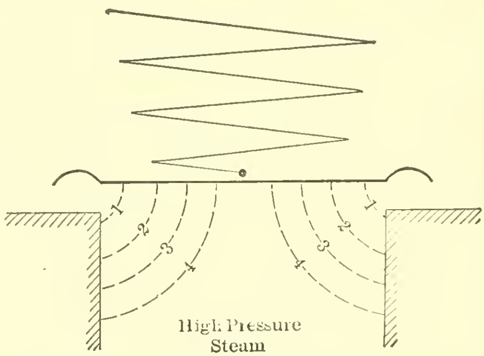

Fig. 16. Showing Varying Pressures Affecting Lift of Valve

bevel seats may be found very closely by the direct application of Napier's equation.

W. Trinks. It occurs to me that the most important part of Professor Miller's paper has been omitted. We can predict with some degree of accuracy how much steam a valve is going to discharge for a given lift, but it takes a very wise man to predict the lift, for this reason: The region around the valve seat is a nozzle so that at line 1, Fig. 16, the pressure will be less than at line 2 and that again less than at line 3, etc.; but the pressure over the whole plate, plus the lip for popping, keeps the valve open against the compressed spring. For heavy flow there must be equilibrium between spring force and static and dynamic steam forces. To pre-

dict the lift of the valve one needs the distribution of the pressure lines 1, 2, 3, 4, etc., over the valve face. While the tests in question were made the distribution of pressure might have been tested. It is desired to know whether such tests were ever made and if so, when they have been published.

A. B. Carhart. The tests were part of the experimental work incidental to proposed improvements in safety valve design, and the measurements obtained were intended to be kept as private information. The purpose was not to determine the maximum amount of steam which could be discharged under any extreme conditions of valve adjustment. The tests give simply the desired positive and quantitative measure of the effect of certain definite modifications of the contour of the orifice at the valve seat, in forms adapted to ordinary commercial uses.

Special care was taken to insure dry steam, and this was shown to be at all times between 0.995 and 0.999 dry, measured close to the safety valve inlet. Obviously the weight of steam apparently passed would have been considerably greater if it had been wet. The steam was measured by condensation of the discharge, for weighing the feedwater would have given only approximations that would not be tolerated in boiler tests or other steam measurements.

The form of the curves, which closely approximate straight lines passing through the origin at zero, indicates well designed proportions of the orifices at the various lifts, and tends to the conclusion that the curves may reasonably be projected further to indicate the discharges for the slightly higher lifts sometimes desired and attained in these valves under actual working conditions.

As the basis of comparison with the results that may be predicted by applying Napier's formula to the calculation of safety valve discharges, the constant derived from Professor Miller's tests might perhaps be more conveniently taken with reference to 70, as used in the ordinary form of Napier's equation, rather than with the transposed value of 51.4 referred to in the form used by Professor Chase. The discharges measured by Professor Miller show a value of the constant of 69.68 as the average of all his measurements of the bevel-seated valves, or a value of 69.93 as the average of the eight tests at the normal lifts of 0.08 and 0.10 in., showing a very close approximation to the value of 70 of Napier's formula. This seems to establish the reasonableness of applying Napier's equation to

the calculation of the discharge of safety valves of the type tested by Professor Miller, but the writer thinks these results will hardly justify the general conclusion stated by Professor Chase that "the discharge of dry steam for valves with bevel seats may be found very closely by the direct application of Napier's equation," for obviously the equation can hardly be directly applied to all valves, since in the earlier tests referred to by Professor Chase, with which he makes comparison, the discharges were apparently only about 92½ per cent of the values given by Napier's formula, as Professor Chase shows.

In comparing the present bevel-seated valves with other valves, Professor Chase disregards the fact that although both are called "bevel-seated" (having the contacting faces at an angle of 45 deg. to the vertical), yet the form of the approach to the seat orifice, and the passages and chambers at the lip of the valve were entirely different in design, the extreme lip of the disk of the valves in the earlier tests turning upward, instead of downward as in the valves tested by Professor Miller, and in other ways differing so that they can hardly be directly compared. Moreover, in the earlier tests, no account was taken of the difference in the expansion of the spindle and the valve body, or of the additional lift due to the pressure of the steam against the disk. Professor Miller shows that these may be considerable in amount. The bevel-seated valves tested by Professor Miller were held rigidly in place by screw threads directly below the seat, ending practically on the level with the steam-tight joint, yet even in this case the additional strain beyond the set opening in the various cases was 0.0007, 0.0010, 0.0015 and 0.0022 in., respectively, which gave an additional area of opening, beyond the amount due to the nominal measured lift, averaging 2.9 per cent and in the maximum case amounting to 7.5 per cent increase. In the case of the flat-seated valves, where the control was about 2 in. above the valve seat (Fig. 2) the additional strain due to the steam pressure beyond the measured lift was in the various cases 0.0024, 0.0044, 0.0022 and 0.0032 in. This is several times greater than in the case of the bevel-seated valves, which were controlled much nearer the valve seat; and this greater percentage of increase in discharge area was found, although the area of the disk upon which the additional pressure was exerted is much smaller than in other valves. If the screw-thread control of the spindle carrying the disk were still further from the

seat, at a distance of perhaps 8 or 10 in., the amount of actual opening of the valve beyond the measured opening as set must inevitably be considerably greater than the amounts determined by Professor Miller, and would thus modify the calculation of the percentage of discharge and the relative value of the constant to be compared with Napier's constant in such cases, so as to have reduced appreciably the apparent indicated percentage efficiency of discharge. In Professor Chase's illustration of the effect of using an erroneous formula, which he says is inadmissible, he applies it to 12 cases out of 24 in Professor Miller's report; whereas in the earlier tests he refers to, it was used in only two cases out of 24. Therefore the value of the constant as then determined could not have been greatly affected.

If it were to be assumed, in the case of the flat-seated locomotive valves tested by Professor Miller, that all of the steam discharged had passed over the outer seat alone, the percentage of the discharge would have averaged 108.5 per cent for the valves having the square edge seat and 121.2 per cent for the valves with the seat having the rounded edge, as compared with the discharge to be predicted for the same areas of discharge orifice, calculated according to Napier's formula, taken as 100 per cent. This simply establishes what has been so often asserted, that approximately 15 to 18 per cent of the total discharge of these valves is through the openings through the hollow arms leading from the central well, by which the amount of the valve lift and the closing pressure are regulated, affording therefore this additional by-passed flow of steam through the central passages, independent of and in addition to the main discharge over the outer flat seat. And there is the other interesting comparison, that by reason of these seats being flat, instead of beveled at an angle of 45 deg., the calculated discharge orifice, for the same lift, is nearly 1½ times as great as in the valves of the same seat diameter with the 45 deg. angle.

The original and only purpose of Professor Miller's tests of the locomotive valves was to determine the actual increase in the rate of steam discharge due to rounding the edge of the valve seat. In order to measure exactly the effect due entirely to this change in design, it was necessary to remove the springs and to secure the valve disks at the predetermined lifts. When such valves are operating in ordinary service with the usual springs the amount of lift is undoubtedly not always the same and is not

uniformly maintained throughout the period of blowing; nevertheless these tests do establish the fact that if these valves are regulated under the operation of the spring so as to lift 0.05, 0.08 or 0.10 in., as may be desired, then the steam discharge must

TABLE 5 BEVEL-SEATED, IRON-BODY VALVES AT 100 LB. AND 150 LB. WORKING PRESSURE. AS TESTED BY PROFESSOR MILLER

Size of Valve, In.	Actual Lift	Area of Orifice at Seat Opening	Average Boiler Pressure	Discharge in Lb. per Hour Measured by Tests	Discharge in Lb. per Hour Predicted by Napier's Formula for Given Area and Pressure	Discharge, Percentage, Efficiency upon Napier's Predicted Discharge	Equivalent Constant —Compared with Napier's Value 70
3	0.0207	0.1384	110.4	879	890.43	98.72	70.92
3	0.0507	0.3406	109.2	2219	2170.30	102.24	68.49
3	0.0807	0.5447	108.3	3500	3445.61	101.58	68.96
3	0.1007	0.6820	109.8	4412	4366.75	101.04	69.44
3	0.0210	0.1404	161.9	1313	1275.15	102.97	68.02
3	0.0510	0 3426	154.9	3049	2988.26	102.03	68.49
3	0.0810	0.5468	152.2	4670	4693.42	99.50	70.42
3	0.1010	0.6840	151.3	5788	5839.40	99.12	70.42
3½	0.0215	0.1676	110.2	1058	1076.57	98.28	71.42
3½	0.0515	0.4031	105.0	2488	2481.48	100.26	69.93
3½	0.0815	0.6407	102.0	3878	3845.30	100.85	69.44
3½	0.1015	0.8001	102.4	4788	4818.43	99.37	70.42
3½	0.0222	0.1730	152.2	1504	1484.93	101.28	68.96
3½	0.0522	0.4086	151.1	3518	3184.07	100.97	69.44
3½	0.0822	0.6462	154.9	5616	5636.34	99.64	70.42
3½	0.1022	0.8057	147.4	6746	6716.77	100.43	69.93

Average of 16 tests, percentage efficiency 100.517
Average of 8 tests, at normal lifts of 0.08 and 0.10 only 100.191
Average of 16 tests, equivalent value of constant 69.68
Average of 8 tests, at normal lifts of 0.08 and 0.10 only.................... 69.93

Orifice areas calculated by full formula, $A = 2.22\,Dl + 1.11\,l^2$.

Data taken from Professor Miller's test of 1910.

Showing rates of discharge slightly exceeding rate predicted by Napier's formula, but fairly confirming its accuracy, as applied to these values.

Napier's formula, W (per second) $= \text{Area} \times \dfrac{\text{Abs. Press.}}{70}$

inevitably be at the rates given in this report. He showed for example that the valves with the rounded seat edge discharged an average of 11.5 per cent more steam than the valves with the square edge seat, the increase being 12.3 per cent in the case of the 3-in. locomotive valve at 0.05 and 0.10 in. lift.

As it was not Professor Miller's purpose in measuring the discharges of the bevel-seated and flat-seated iron-body valves, to make any direct comparisons with the results of the tests of any other valves or with any other experiments made at different times for other purposes, the writer has not attempted to present any such calculations. But the actual measurements showed an average discharge by the flat-seated iron-body valves 46.5 per cent greater than in the bevel-seated valves at the same fixed lifts: the increase, for example, averaged 52.2 per cent in the case of the 3-in. valves at 100 lb. pressure. The discharge of all the 3-in. flat-seated valves was 49.5 per cent greater than of all the 3-in. bevel-seated valves, and the average increase was 49.2 per cent in the case of all flat-seated valves of both sizes at 100 lb. pressure.

Table 5, showing the comparison of Professor Miller's results with the discharges to be predicted by applying Napier's formula to the nominal discharge areas through the seats of the bevel-seated valves, may be of interest.

E. F. Miller desires to present no closure.—EDITOR.

THE PRESENT STATE OF DEVELOPMENT OF LARGE STEAM TURBINES

By A. G. Christie, Published in The Journal for May

ABSTRACT OF PAPER

This paper deals with the present state of development of leading types of large steam turbines, some details of construction, the commercial results obtained and some new uses to which steam turbines have been put. It also points out the probable tendencies of steam-turbine development.

For the purposes of discussion, large steam turbines are divided into two types, fundamental and modified or combined. The weak elements of the fundamental types are discussed and the advantages of the new types pointed out. Some new constructons are shown in section.

The details of construction are discussed fully. A table with brief notes on the details of construction of individual types is included for rapid comparison of the practice of various manufacturers. The different types are also compared on the basis of efficiency as shown by published results of tests.

The present status of low-pressure turbines, turbo-compressors, turbo-driven pumps, geared turbines and marine turbines is discussed briefly. The closing paragraphs deal with the probable trend of steam turbine development and future possibilities.

DISCUSSION

F. Hodgkinson. In the table showing the characteristics of turbines of different manufacturers there are certain points that the writer would like to add to or correct in reference to the machines built by the Westinghouse Machine Company, first respecting speeds.

Speeds have been increasing lately for 60-cycle work. For sizes of from 3000 to 10,000 kw. 1800 r.p.m. is the speed employed and for larger powers, 1200 r.p.m. For 25-cycle work, 1500 r.p.m. is employed up to a rating of 15,000 kw. (normal), or 20,000 kw. (maximum). A speed of 750 r.p.m. is not likely to be employed for capacities of less than 30,000 or 40,000 kw.

The American Society of Mechanical Engineers, 29 West 39th Street, New York. All discussion is subject to revision.

The speed of impulse blading, as employed by the Westinghouse Company, varies with the different types from 350 to 500 ft. per sec. The speed of the reaction or Parsons blading at the low pressure depends upon the steam volumes involved and varies from 300 to 500 ft. per sec., the latter in the case of large machines where constriction in the exhaust must be avoided on account of the large volume.

The journal speeds are higher than Professor Christie points out. Journal speeds reach 80 ft. per sec. and pressures 100 lb. per sq. in. of projected area, and this pressure may be materially increased without encountering wear of the bearings, provided the proper flooded lubrication is employed and bearings are sensibly designed. With higher surface speeds a little more oil-cooling capacity will be necessary on account of the greater rate of shear of the oil. A good warm temperature, not less than 150 deg., is conducive to high economy.

Concerning the economies of turbines, Professor Christie quotes the opinion of European engineers, that higher economy is to be obtained from impulse elements of the Rateau or Zoelly types, rather than with impulse elements of the Curtis design. The writer believes this to be a generally accepted fact and in the case of the latter type is doubtless due to the low efficiency of the last row of moving blades. Apparently having once expanded, steam eddies are brought about each successive time the steam is put through the blade elements. Somebody has remarked that the fourth row in a Curtis element has never been found useful. Theoretically it is useful, but in practice, except for very high pressure drops, it has not been found so.

It would seem that the reaction turbine, unless it be subjected to some disability, may be more economical than either of the other types. With any impulse turbine there are necessarily two complete conversions of energy, the first expanding the steam through the nozzle, the steam doing work in giving itself velocity; and the second extracting the velocity of the steam. Both of these transformations of energy are subject to losses, the second greater than the first. If the nozzles were permitted to revolve, and the turbine had no blades at all, obviously such a turbine would be the more efficient. The reaction or Parsons turbine is such a machine, but, unfortunately, it is subject to leakage. However, with higher speed machines and capacities that lend themselves to good proportions of blading, this leakage, particularly

at the low-pressure end, is a very small factor, and such a turbine is the more efficient. These features are emphasized in the later high-speed turbines, particularly of the combination type, comprising a Curtis turbine element for the high pressure, and a reaction element for the low pressure, the Curtis element as referred to the regular Parsons, replacing a large number of rows of reaction blading at a small diameter with the attendant greater axial length, or a smaller number of rows of larger diameter, the blades being smaller in the latter case, and of poor proportions, subject to high leakage.

Of late, the tendency has been toward higher speeds, which, within reasonable limits, is conducive to better results, not only from the standpoint of economy, but also from the standpoint of operativeness. As Professor Christie has stated, congestion at the low-pressure end may be entirely avoided by making the last portion double-flow. Higher rotational speed involves smaller diameters, and hence better blade proportions at the high pressure end, with the attendant lesser leakage. In addition to this, the turbine cylinder structure as a whole is much smaller, there is less distortion of structure with temperature changes, thus permitting running the blades with smaller clearances if it is desired to do so.

Professor Christie very properly points out that there is a lower leakage ratio in a single-flow turbine than in one of double-flow construction. However, the choice of revolutions is limited on account of the standard frequencies employed. While reducing the speed to the next lower one available may permit of single-flow construction, the advantages may be entirely offset by the increased clearances which must be employed, simply because the size of the machine has so materially increased, with the attendant greater amount of distortion. Therefore, the turbine having the low-pressure sections double-flow is frequently the more economical machine. It is very convenient to be able to double up the steam passage at the low-pressure end, because of the tremendous rate with which the volume increases, particularly with machines designed for high vacuum.

Concerning blade troubles and blade construction, the writer ventures the statement that no turbine built by a reputable manufacturer in this country ever came to grief because of the blades becoming detached or breaking, due in itself to centrifugal force. Accidents have occurred because of misalignment or distortion,

resulting either in blades colliding with turbine parts, or with one another, which of necessity resulted in injury. The principal source of blade trouble is due to the blades buzzing or vibrating in the steam current. The natural vibrating period of the blade may be raised by means of a shroud, or other form of lashing, but not eliminated.

Fig. 12 shows what has now become the standard construction for reaction blading, as employed by the Westinghouse Machine Company. The feature is an interlocking system, the strength of which is equal to that of the blade itself. The blade sections are stronger at the root than at the tip. The section tapers

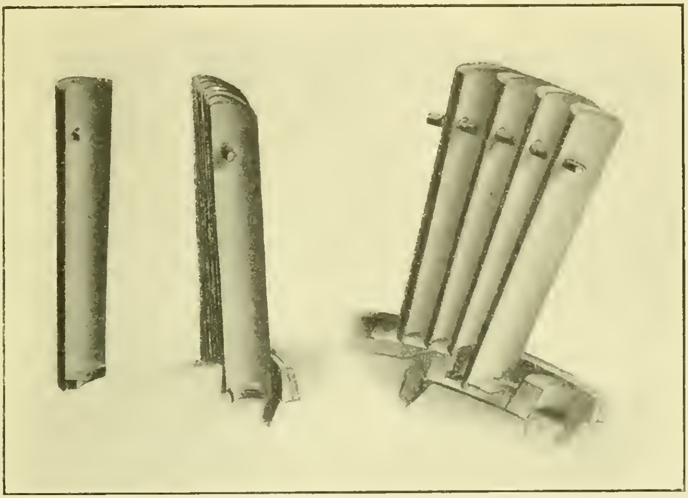

Fig. 12 Blading Used in Westinghouse Turbines

slightly from the root, thus eliminating the chance of injury due to any vibrating or buzzing, should it exist.

As shown in Fig. 12, the bottom end of the blade is upset, which is truly an upsetting process, and not any mere bending, and the die for holding the blade at this time is so arranged that the section of the blade is increased in thickness throughout its lower portion, this latter feature, however, not being clearly shown in the illustration.

The dove-tailed groove in the blade carrying member is provided with a supplementary groove in the floor of the main groove, into which fits the upset end of the blade. The latter locks underneath the packing pieces which occupy the main

groove. The larger blades are provided with compound wedges which go between the walls of the groove and the blades and packing pieces, which effectively fills the groove in a more satisfactory manner than a calking strip. In the case of the smaller blades, the wedges are found to be unnecessary, owing to the lighter sections of the packing pieces, which permits them to fill the groove, when driven into place. Inasmuch as no calking of any kind is resorted to, blades may be taken out and replaced an indefinite number of times.

The author has brought out an important point in the matter of standardization of ratings for turbines, and suggests that the Society fix a rating for turbines, defining their overload capacity. While this may be a little difficult to do, the writer cordially concurs with him that a great deal of confusion exists.

In discussing capacities of machines, one is compelled to go to some explanation as to what is meant. The kilowatt rating needs as much explanation as does the load factor.

Present methods cause particular confusion in the statements of the cost per kilowatt of the installation of a turbine station. To standardize ratings may be difficult unless the turbine be dissociated from the generator. There are, however, two needs of ratings for power-plant work today. One is for the very large power plants, such as the Edison plants, which have a large number of units and large capacity, and the condition is such that if the machine is running at all it is running at its highest load. Obviously a generator in such a plant may advantageously be given a certain maximum continuous rating at a specified temperature rise, and the turbine connected to it arranged to give its highest economy at that load, and need have no overload capacity, or at most 10 or 15 per cent.

The other kind of rating required is that needed by the smaller plants with few units, the plant having to encounter heavy peaks at certain times of the day. Here, while the generator may have a certain maximum capacity as to its basis of rating, the turbine should have its highest economy at some fraction of this load. For such an application the old method of rating machines at a normal full load, with a 60-deg. rise, would seem to apply to the turbine having its best economy at that load and the generator capable of carrying 25 per cent overload continuously and both turbine and generator capable of running for a limited time at 50 per cent overload.

That system of rating was first practised in this country in the early days of turbine development and had not been practised in Europe. It was brought about by the turbine having to compete with the Corliss engines. Latterly, bargain-counter methods of buying (an expression borrowed from Professor Christie) have caused such outfits to have their turbines sometimes given a maximum rating corresponding to the 50 per cent overload just referred to. It would seem entirely feasible to have generators uniformly rated on maximum continuous load basis; the turbine, however, to have its best steam consumption at some fraction of this, depending on the requirements of the installation, and with overload capacity to suit the maximum possible load on the generator.

J. A. Moyer. Interest in Professor Christie's paper, in the writer's opinion, centers about his tabulation of recent tests of steam turbines. Such a tabulation is, however, scarcely complete if it does not include the very elaborately detailed and accurate test of a Sulzer turbine, of the combined impulse reaction type, reported by Professor Stodola.[1] At the load showing the best economy, 2058 kw., the steam consumption was 15.21 lb. per kw-hr.; speed was 1501 r.p.m.; absolute steam pressure, 178.1 lb. per sq. in.; superheat 182 deg. fahr.; vacuum referred to 29.92 in. barometer was 28.41 in. (0.740 lb. per sq. in. absolute pressure). Calculated from these data the b.t.u. per kw-hr. on the basis explained in Par. 69, are 18,800; the heat utilized per pound of steam 224.5 b.t.u.; the available heat per lb. of steam 380.1 b.t.u.; and the efficiency ratio or the efficiency of the Rankine cycle is 59.1 per cent. The generator efficiency was low for a machine of this size. This is certainly a reliable test of a presumably well-designed turbine of the Curtis-Parsons type, and the results are not particularly favorable when compared with the data ordinarily published by manufacturers or their agents. It should be clear, therefore, that the adoption of a design consisting both of impulse and reaction stages along with excellence of constructive details does not necessarily give higher efficiencies of the Rankine cycle than other types. The Sulzer turbine, however, was laboring with one disadvantage in that it had three rows of moving blades and two rows of stationary blades instead of the modern Curtis construction employing two rows of moving and one row of stationary blades per pressure stage. Furthermore, it has

[1] Zeits. des Vereines deutscher Ingenieure; October 28, 1911, p. 1799.

never been shown that anything is gained by attaching to a blade wheel more than two rows of moving blades or buckets.

The writer felt that tests reported as showing Rankine efficiencies greater than about 68 per cent should be accepted only with a great deal of caution. To be more definite, he was not sure that the data of the first, third and fifth tests reported in Table 2 might be accepted without reservation. All of these tests are nothing more than manufacturers' statements, not properly verified. At a glance one might suppose that the second of these tests, taken from a descriptive article in the Zeitschrift des Vereines deutscher Ingenieure, came with some basis for consideration, but the test itself does not bear the earmarks of one made with very much accuracy. Practically all the data are given in round numbers, usually indicating approximation. As stated, the load is exactly 6000 kw., the steam pressure is given roughly at 13 atmospheres absolute, the steam temperature averaged apparently exactly 300 deg. cent. at the throttle throughout the test, and the steam consumption per kw-hr. was calculated not much closer than the nearest half-pound. As regards the fourth test cited, the writer is inclined to agree with Mr. Emmet in his statement at a previous meeting of the Society when this test was being discussed, that the "data are not altogether convincing." It seems to me that we should be very careful about incorporating into the Transactions reports of tests of boilers, engines and turbines supported only by the claims of manufacturers. It is very desirable that such tests should be made and reported by well-known engineers who have no financial interest in the business.

The statements in Par. 10 are not very clear as regards erosion or cutting of the blades. There is very little erosion of the blades in either the Curtis or the so-called Curtis-Parsons types if constructed of what are now considered by experts as suitable materials. The constant erosion of *continuous operation* for five years will have very little effect on the economy of the turbine as compared with the corresponding deterioration of a reciprocating engine.

The writer objected to another manufacturer's claim as given in Par. 51, where it is stated Mr. Zoelly "claims he gets the best results on his turbine by throttle governing." The Zoelly method of governing is cheap and simple, and that as the writer understands it, is the reason for its adoption. The writer would like to be shown, however, by authentic tests that it is even nearly as good as some other types.

C. V. Kerr. In Par. 10 there is a statement as to the wear of the blading in the lower stages being due to the wetness of the steam. In the double-cup form of turbine in which the writer has been interested, the wear of the blading was found to be in the upper stages. This may be due to the fact that a greater proportion of the available energy was allowed to produce velocity in the upper stages, with the idea that part of it would be transferred to the lower stages, and thus equalize the power. Or it may be that the erosive power of the steam is greater in these upper stages, due to its greater density. It is a question whether it is possible to equalize this wear throughout the stages by an exact division of the available energy.

In his connection with the small turbine business the speaker had to do with the driving of auxiliary generators, pumps and blowers. He took the stand that his company wanted to know the maximum power to be developed by a turbine, then they would on their test put into the turbine a little more than that maximum power to make safe. It is very important for that class of work and he thought it should be for generator work also. A generator is supposed to stand a certain normal overload for a certain period. What is the use of putting into a turbine more power than is required to move the generator at that power and thus cause a burning out or other difficulties? The small steam turbine builders dropped into the habit of selling their turbines on the basis of power developed. With a casing of a given size, however, the power may be doubled or quadrupled by adding nozzles. But the small steam turbine is in competition with the steam engine and the electric motor, and they are generally sold on the power basis. It is the practice now on the part of at least two of the small steam turbine builders, to establish a minimum price for the turbine based on manufacturing cost and a rating upward on the basis of additional power developed.

Regarding the manufacturers' tests, there are members of the Society engaged in the manufacturing business whose study of testing methods is as intense and of as high an order as any who are doing testing. Questions are being raised as to standard methods of testing which come from manufacturers' engineers engaged in testing. There is no monopoly of engineering honor in one particular section of engineers. Although a manufacturer's engineer, the writer stands in favor of accepting all engineers' tests on their full value, for it is a mark of engineering

honor and a recognition of honor in others. He also believes that it is a mistake on the part of any engineer to put out data that are tainted in any way, since this will react on the offender sooner or later.

George A. Orrok referred to Professor Moyer's expressed doubt of the figures given in Table 2 of the paper for the Erste Brunner turbine. The results had seemed to him to be extremely good, and he had investigated them by writing to the engineer who made the tests, Professor K. Koerner, rector of the German Technical High School at Prague, who vouched for the data.

Clarence P. Crissey.[1] The accepted practice is to divide turbines into two fundamental types, namely, reaction turbines and impulse turbines. While these names may not be free from criticism, they are well understood and seem preferable to the names Parsons, Curtis and Rateau. While the latter terms give credit for inventions or variations in design, they are not based upon fundamental principles and, therefore, seem undesirable.

If it is desired to subdivide impulse turbines according to the manner of utilizing the steam, the following classes are suggested:

a Impulse turbines with only one velocity stage in each pressure stage

b Impulse turbines with two or more velocity stages in each pressure stage

c Impulse turbines in which all pressure stages do not have an equal number of velocity stages

Classification of impulse turbines might be carried further in order to illustrate a point of construction often overlooked: that is, the method of conducting the steam leaving the last buckets to the succeeding nozzles. Various constructions are:

d Impulse turbines in which the steam leaving the last moving buckets passes directly from the bucket into the succeeding nozzles without great loss of velocity

e Impulse turbines in which the steam leaving the last moving buckets passes into the casing and after losing practically all of its velocity enters the next set of nozzles

f Impulse turbines in which the steam leaving the last

[1] General Motors Co., Detroit, Mich.

moving buckets is utilized in some pressure stages according to the method described in *e* and in other pressure stages according to the method outlined in *d*

It follows from this classification that Rateau turbines fall in class *a-d;* Zoelly turbines fall in class *a-d;* Curtis turbines of the General Electric Company fall in class *b-d;* Curtis turbines of A.E.G. (large size) fall in class *c-f*.

The Zoelly turbine is similar in principle to the Rateau and it seems preferable to class the Zoelly turbine as a Rateau type just as the Allis-Chalmers is called Parsons and not Fullager.

It will be noted that in the paper the single-row stages of the A.E.G. turbines are said to be of the Rateau construction. The Allgemeine Electricitäts-Gesellschaft, however, state that these stages are constructed in accordance with the 1896 patent description of Curtis which represents the immediate forerunner of the Rateau and Zoelly constructions. The difference between the A.E.G. single-row stages and those of Rateau consists in the manner in which the steam leaving the moving buckets is utilized. This difference has been noted in the classification of turbine types given above, that is, the A.E.G. single bucket row stages are of type *d*, in which the steam leaving the moving buckets passes directly into the succeeding nozzles without great loss in velocity while the Rateau fall under type *e*, in which the steam is brought to rest before entering the next set of nozzles. The large A.E.G. turbines, therefore, appear to be of the Curtis type throughout, although not altogether of the type popularly known as Curtis.

The moving buckets of reaction turbines have in practice been supported upon drums and those of impulse turbines usually upon disks. The manner of construction does not, however, change the fundamental type and, therefore, the author's designation in Par. 24, of the Belliss & Morcom turbine as a Curtis-Parsons construction is confusing because this turbine operates entirely upon the impulse principle.

In reading Par. 5*b*, the impression might be gained that high steam velocities are inherent with impulse turbines having two or more velocity stages. Such is not necessarily the case. If low bucket velocities are employed the spouting velocity of the steam is also low. Impulse marine turbines illustrate this point.

It might be inferred from the last part of Par. 12 that constructions such as the A.E.G. sacrificed efficiency to first cost.

According to Table 2 the A.E.G. design is more efficient than the Rateau.

In Par. 22 reference is made to Fig. 3 showing a turbine with six pressure stages. It is stated that the A.E.G. build similar turbines up to 1000 kw. capacity. While the A.E.G. machines below 1000 kw. have two velocity stages in a pressure stage the writer understands that they have only two pressure stages.

It would be interesting if Professor Christie could tell whether Mr. Zoelly advances any reason for his claim of greater efficiency with throttle governing.

In connection with Par. 35 it might be observed that theoretically correct action of the steam in any impulse turbine occurs only at one set of conditions. For any variation in conditions or quantity of steam flowing a variation from the theoretically correct action must occur. The flat economy curves of impulse turbines prove that this is not important from the standpoint of efficiency, and practice shows that the end thrust is not appreciably increased by departure from the theoretical conditions.

The drum construction in impulse turbines was probably first used by the A.E.G. in the turbines for the steamship Kaiser, which was tested in 1905. This firm's experiments led them to state that the drum construction was advantageous, for the low bucket speeds existing in direct-connected marine turbines when the steam had expanded to 50 times its initial volume.

Using the fundamental classification given in this discussion there is only one type of "modified" or "combined" turbine, that is, the impulse-reaction machine.

It is interesting to examine the evidence as to which of the fundamental types is at present gaining in popularity. There is conclusive evidence that a large number of manufacturers formerly producing reaction turbines have adopted impulse blading in the high-pressure sections of their machines but there is little to indicate that the manufacturers of impulse turbines generally contemplate introducing reaction blading.

Par. 105 states that "several impulse turbines have recently been built in Europe where the expansion was not complete in the nozzles, so that a portion of the expansion took place in the first moving blades." The only turbines of this character which the writer knows of were abandoned and if others are being built they probably are more or less of an experiment.

In Par. 70 the following statement is made: "It is therefore

apparent that the efficiency ratio alone will express in the best manner the degree to which the designer has approached ideal results in his turbine." While the efficiency ratio comes nearer than any other single figure to expressing the economic results it must be used with caution because:

a *The steam conditions must be taken into account.* The same steam turbine operating with an equal amount of available energy will not have the same efficiency ratio if the energy is obtained in one case by a moderate vacuum and high superheat, and in another case by a high vacuum and low superheat.

A non-condensing turbine may have the same or a better efficiency ratio than a condensing machine, but this is no indication that the non-condensing turbine is as suitable or better for a given plant than the condensing unit.

b *It is more difficult to obtain a high efficiency ratio with a large amount of available energy than with a smaller amount.* Referring to Table 2 it is seen that the 6000 kw. machine, built by Erste Brünner M.F.G., has an efficiency ratio of 71.3 and the heat available per pound of steam is 380.7 b.t.u. The A.E.G. turbine of about the same rating gives an efficiency ratio of 68.7, but the heat units available per pound of steam are 434.2 b.t.u. or about 14 per cent greater. If the latter machine were operated with steam having 380.7 b.t.u. per lb., there is little doubt but that the efficiency ratio would equal or approach closely that of the Erste Brünner turbine.

c *The efficiency of the electrical generators is included in the efficiency ratios.* This has considerable importance if the ratios are used to compare turbine types. It is stated in Par. 59 that European builders generally guarantee better generator efficiencies than American builders.

d The results may be affected by the inclusion or exclusion of the power necessary for field excitation and auxiliaries, as well as other variations in testing practice.

From a technical viewpoint the revolutions per minute of the turbines cannot be neglected in making comparisons upon which to base opinions as to types. Either type is benefited by an in-

crease of rotative speed and it is almost certain that in the future the speed of all types will not differ materially for machines of a given rating and service.

Too much reliance must not be placed upon efficiency ratios, either in the selection of a turbine at the present day or as a basis of judgment regarding ultimate types because first cost, reliability, sustained economy, life and operating expenses are such important factors. The author points out, and it is well to emphasize the fact, that his figures for efficiency ratio do not represent operating conditions such as occur with varying loads or the average economy of any type of turbine.

E. D. Dreyfus emphasized the necessity of establishing some method of ratings which would be recognized by engineers at large, and also rules for conducting tests of this type of power generating unit, that is, including the turbine and generator as a whole. As the paper states the case there is now an undesirable dissimilarity in practice in rating this class of machinery.

The Society should lay down some guide or formulate some code which would create more uniformity and a better understanding in this connection. Failure to do this will leave room for criticism, which seems already to have shaped itself in the minds of some. It is well to note how this situation has been viewed by others, and the writer quotes a very brief abstract from an editorial from the Electrical Review and Western Electrician [1] under the heading of Ratings, which followed a paper he read one year ago on Turbines in which this vital question was seriously referred to:

> There are a variety of bases upon which ratings may be made. The ultimate capacity of the machine is one basis, the load at which maximum efficiency is secured is another, the load at which deterioration is less is another, the load which is fixed by some limitation of operation is another, and so on. Most electrical apparatus is limited in capacity by the allowable temperature rise and the rating is made upon this basis. The Standardization Rules of the American Institute of Electrical Engineers fix the allowable temperature, and performance specifications are drawn to coincide with these rules, or else specify limiting temperatures considered more suitable for the given working conditions. * * *
>
> Turning to steam engines we find the rating to be based upon operation at maximum efficiency and normal speed. * * * Practice is not entirely uniform here, however, and there is a certain leeway dependent upon

[1] October 14, 1911.

personal opinion or the characteristics of the particular engine. In any case, there is ample margin to take care of overload and a fairly definite general understanding as to what the rating signifies. * * *

With the steam turbine, on the other hand, there is no such general understanding and uniformity of practice, and it is not safe for the operating steam engineer to assume that a turbine with a given rating is capable of carrying the same overload that may be saddled upon the reciprocating engine of the same rating. * * *

* * * A uniform method of rating should be adopted just as quick as possible and nobody is in a better position to determine what that method should be than The American Society of Mechanical Engineers. By adopting such rules concerning steam machinery as the Institute of Electrical Engineers has done for electrical machinery, it will perform a real service to the country. * * *

Carl Geo. de Laval. A new steam turbine has lately been designed on quite radical lines by Messrs. Ljungstrom, Stockholm, Sweden. It is a radial flow reaction turbine with steam entering between two disks passing from center to circumference between concentric blading rings. These two disks revolve with their shafts at the same rate of speed, but in opposite directions. At the end of each shaft an electric generator is attached. By doing this the relative speed of each blade becomes double the amount of the ordinary reaction turbine of the same number of revolution and diameter, with the consequent result that the blade rows become only one quarter as great. The general result is a turbine of small dimensions for the power and consequent smaller floor space even with the generators included than the present designs now on the market. Several turbines have been built and are being built.

The first turbine was 500 kw. at 3000 revolutions, which gave an efficiency value of 71.8 per cent and steam consumption 8.75 lb. per b.h.p. per hr., with steam of 175 lb. absolute and 250 deg. fahr. superheat and vacuum 28.5 in.

Sizes from 1000 to 7500 kw. with speed of 3000 revolutions have been designed on this double-rotating principle. Single rotating turbines of the same design have also been brought out, but with slightly less efficiency and increased steam consumption, the latter being about 10 per cent comparing the recorded efficiency ratio given by the author. Erste Brünner M.F.G. on a Curtis-Parsons is the highest recorded at 71.8 per cent, steam 156.2 lb., 1500 revolutions, lb. of steam per kw-hr., 13.82. The Ljungstrom 1000-kw. steam turbine gave 74.7 per cent efficiency ratio, taking steam in front of the throttle valve and 76.9 per

cent behind the throttle valve, steam 162 lb., speed 3000 revolutions, lb. of steam per kw-hr., 11.55 or 8 per b.h.p. It is stated that the critical speed of this turbine is 6300 revolutions, preventing the necessity as in many turbines of passing through the critical speed.

There are many novel details carried out in this turbine. The bottom is so shaped that it is placed directly on the condenser without the use of expansion joints. The two generators are supported on springs or slides on top of the extending ends of the condenser. The blades are of the Parsons type, milled from a solid bar of nickel steel, and having notched ends with blade roots turned over into the rings. In starting, the two sides of the turbine may not run at the same speed, but the exciting currents are strong enough so that at a certain speed the generators will synchronize automatically and run as one unit.

W. L. R. Emmet. In Table 2, which gives a comparison of various turbine performances, injustice is done to the Curtis type, and other incorrect impressions are given. This table is derived from various chance publications, but nothing is known concerning the authenticity of any of them. Such classification by merit as Professor Christie has made therefore ought not to be published without qualification.

The first machine mentioned in this table is a 2000-kw. Curtis-Parsons operating at 1500 r.p.m. and is reported to give an efficiency of 71.8 per cent with a moderate degree of superheat. Everybody familiar with the design of either Curtis or Parsons machines knows perfectly well that no such result has ever been produced under such conditions.

The efficiencies assigned to the five General Electric Curtis machines mentioned range from 63.6 per cent down to 61 per cent. The first, which operates at 3464 kw., is a representative result of the machine in question and is a good performance when the very high vacuum used is considered. Of the other four, only one of the tests is representative when the machine is correctly tested and in good condition, and in that case, also, the extremely high vacuum is the cause of a relatively low efficiency.

In discussing this table, the author states in Par. 70: "It is therefore apparent that the efficiency ratio alone will express in the best manner the degree to which the designer has approached ideal results in his turbine." To this statement exception should

be taken for the reason that it is naturally possible to produce higher efficiencies in turbine construction with moderate degrees of vacuum than it is with very high degrees of vacuum, the limitations to the effective use of high vacuum being many and their extent being affected by speed and capacity. Therefore the designer who produces a relatively low efficiency with a very high vacuum may have accomplished his purpose much more credit-

TABLE 3 TESTS OF REPRESENTATIVE CURTIS TURBINES

Customer	Date of Test	Load, Kw.	R.p.m.	Steam Pressure Absolute	Superheat, Deg. Fahr.	Vacuum	Water Rate, Lb. per Kw-Hr.	Efficiency, Per Cent
		7526	720	184.40	134	28.65	13.732	66.6
Boston Edison Co.	1907	7481	720	185.10	129	28.58	13.866	66.6
Commonwealth Edison Co., Chicago	1907	12000	750	200.00	125	28.00	14.220	66.2
Boston Edison Co.	1912	12460	720	207.50	191	27.52	13.630	68.2
Stock	1911	4000	1800	189.00	0	28.00	16.050	64.3
Louisville Ltg. Co.	1911	6500	1800	180.00	100	28.00	14.780	66.10
British Thomson - Houston, Rugby (maker)	1912	2000	3000	165.00	150	28.00	14.400	67.3

ably than another who has produced a higher efficiency with a low vacuum.

None of the General Electric machines referred to in Professor Christie's tabulation, except the first mentioned, was designed later than 1904, while many of the other makes are of very recent production. Table 3 gives tests of a few representative Curtis machines. The first two tests apply to machines in Boston, very carefully and repeatedly tested when they were comparatively new. These machines are of the same date and type as most of those to which the figures in Professor Christie's tabulation purport to apply, and are representative of the original large 5-stage vertical units when correctly tested and in good condition. These tests were made with very perfect facilities by the Boston Edison Company's engineers.

The third test applies to an 8000-kw. machine in Chicago of the same date and type. One of the tests in Professor Christie's paper also purports to refer to this machine under different conditions.

The next three items refer to recent six-stage Curtis machines, and the last refers to a three-stage Curtis machine recently produced by the British Thomson-Houston Company. This latter machine produces a very remarkable result when its small capacity and extreme simplicity are taken into consideration.

The accurate testing of steam units is a matter which requires great care and is susceptible of many kinds of error. Many figures concerning such tests which are entirely incorrect are being constantly circulated. It is only by comparison of many tests and careful observance of consistency as to results and characteristics that one can ever be sure as to turbine economies. The figures given in Table 3 have been analyzed and compared and are unquestionably correct. It will be observed that they give an impression concerning the value of Curtis turbines which is very different from that produced by Professor Christie's tabulation.

The author's closure is to be published later—Editor.

A NEW ANALYSIS OF THE CYLINDER PERFORMANCE OF RECIPROCATING ENGINES

By J. Paul Clayton, Published in the Journal for April

ABSTRACT OF PAPER

Our knowledge of the cylinder performance of reciprocating engines is obtained almost entirely from indicator diagrams. These diagrams provide a measure of the work performed, thus enabling the efficiency or economy of the engine to be determined; they also provide an aid for setting valves, and furnish the basis in steam cylinders for applying Hirn's analysis, for measuring the initial condensation, and for finding the diagram factor for the purposes of design. It has been generally thought by engineers that the evidence contained in the diagram was limited only to these and minor uses.

The investigation described in this paper has disclosed the fact that the indicator diagram contains in itself the evidence necessary for an almost complete analysis of cylinder performance, the results of which have not heretofore been considered possible.

In obtaining these results the diagram has been transferred to logarithmic cross-section paper and thus a figure has been drawn which will be called a logarithmic diagram. By the aid of this diagram it has been found that the expansion and compression curves of all elastic media used in practise obey substantially the polytropic law $PV^n = C$. From this fact there have been developed rational methods of approximating the clearance of a cylinder, of closely locating the cyclic events, and of detecting moderate leakage with the engine in normal operation.

It has been discovered that the value of n in the law $PV^n = C$ is controlled directly in steam cylinders by the value of the quality of the steam mixture at cut-off, called X_c, and that the relation of X_c and n is practically independent of cylinder size and of engine speed for the same class of engine. This fact enables us to determine the actual amount of steam and water present in a cylinder at cut-off from the experimentally determined relations of X_c and n, and thus to obtain the actual steam consumed from the diagram.

The paper contains an exposition of the graphical methods employed, charts giving the relations of X_c and n for determining the steam consumption from the diagram, and examples of typical logarithmic diagrams.

The American Society of Mechanical Engineers, 29 West 39th Street, New York. All discussion is subject to revision.

DISCUSSION

Arthur L. Rice said that Mr. Clayton's paper for the first time gives the engineer a chance closely to keep track of what the engine is doing at all times while it is in actual operation. He had had occasion to use this method since the publication of the paper in The Journal. In the use of a high pressure of steam in the engine and a high speed, where the indicator card is a small one, it is absolutely essential that very great accuracy should be observed; otherwise the indications as to the amount of steam consumption may be quite misleading. As to the percentage of accuracy of this method as compared with weighing the steam from the surface condenser, Mr. Rice found from tests that the variation was from 2 to 6 per cent. The logarithmic curve may be plotted directly in inches, without reducing the volume to cubic feet. The only volume of interest is that at cut-off, which is a single volume and easily computed. It is, however, necessary in all cases to take care that the logarithmic paper used is accurate, which is often not the case with the paper in the market.

R. C. Stevens disagreed with Mr. Clayton's treatment of the problem of leakage, and questioned where the author takes into account the leakage of steam directly out of the exhaust, or that part of the steam which enters the steam chest but, by reason of the valve leakage, passes directly out of the exhaust without entering the cylinder. That this loss is enormous, even in many new engines, is too little appreciated. For example, in a case quoted by Mr. Stevens from an article by George Mitchell in Power, October 11, 1910, it was as high as 22 per cent in an engine specially fitted by its makers with a new valve. What is true of piston valves is doubly true of the flat balanced valve with pressure plate. Test on one such engine of 80 h.p. capacity which the owners considered in good condition showed 624 lb. steam leakage per hour, or about 21 h.p. wasted, or over 25 per cent. leakage. It is common practice to allow 0.003 to 0.004 in. freedom between the valve and pressure plate when newly fitted, and in operation the valve wears small and the seat wears large. Altogether, valve leakage is far more important than piston leakage, which may be almost negligible for years. Mr. Stevens therefore challenged Mr. Clayton's assertion that steam con-

sumption may be approximated from indicator diagrams to within an average difference of less than 4 per cent from the test results, and only in rare cases as much as 8 per cent. For, if 20 per cent or more of the steam that enters the throttle goes out of the exhaust without making its presence felt in any way on the indicator, it is difficult to understand how any analysis of the indicator diagram or its derived logarithmic diagram can establish the actual steam consumption of an engine to within even 20 per cent of accuracy.

Sanford A. Moss pronounced the paper to be the first new thing on steam engines for many years, but insisted on the necessity of taking leakage into account. Steam engines are seriously hampered by leakage and when this occurs Mr. Clayton's method cannot be entirely depended upon, unless suitably modified. In the paper an attempt is made to give a variation of the law with pressure, and it did not seem to him that the tests warrant any distinction between different pressures and that the author should use the equation from the average of all pressures rather than the chart of Fig. 6.

R. C. H. Heck. In the logarithmic diagram as a means of investigation, in the proposition that exponent n is practically constant for the respective curves of a particular steam diagram, and in establishing a definite relation between n and quality at cut-off, this paper makes three distinct contributions to the field of research and knowledge which lies between the performance of the actual engine and that of the ideal engine with a non-conducting cylinder. In this region, rational deduction from simple premises is not available, chiefly because it is not possible to simplify and make definite the needed premises: consequently, theory can be built up only by such formulation of empirical results as is here undertaken.

To say that n varies widely with different conditions of working is merely to give special form to a statement of long recognized fact. We know that the approximation of actual expansion and compression curves to the equation $PV = C$ is very rough. A common range of variation with saturated steam is from 5 to 10 per cent, while in extreme cases the product PV departs a good deal farther from constancy. Nevertheless, the hyperbola has been and will continue to be a useful reference

curve, not from any sanction in theory, but simply because it represents constant PV.

Critical judgment upon the method derived and proposed for estimating actual steam consumption could be given only after extensive trial and use. The showing in Table 4 seems to be very favorable. Manifestly, the scheme is as yet incomplete, since the service chart, Fig. 6, is limited in application to one exhaust pressure. In working along the older line of a formula containing size, speed, cut-off ratio, and range of steam tempera-

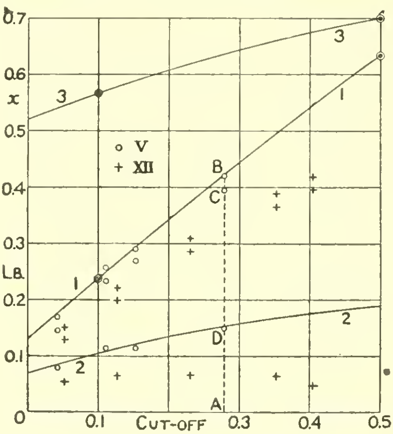

FIG. 26 PLOT OF STEAM QUANTITIES PER REVOLUTION ON CUT-OFF AS BASE, FROM TEST SERIES V AND XII, TABLES 1 AND 2

CURVE 1, ORDINATE AB, TOTAL STEAM PRESENT DURING EXPANSION, MADE UP OF MEASURED CONSUMPTION AC PLUS CLEARANCE STEAM CB.

CURVE 2, ORDINATE AD, MISSING STEAM AT CUT-OFF, FOUND BY SUBTRACTING INDICATED STEAM BD FROM TOTAL STEAM AB.

CURVE 3, CUT-OFF QUALITY x_c, CORRESPONDING WITH CURVES 1 AND 2.

CURVES ARE DRAWN FOR THE SATURATED STEAM TESTS ONLY; EXTENSIONS TOWARD THE RIGHT ARE GUIDED BY THE FORM OF OTHER SERIES, WHICH HAVE LONGER RANGES OF CUT-OFF; THE CIRCLED DOTS ON ORDINATES AT 0.1 AND 0.5 CUT-OFF SHOW VALUES USED IN THE EXAMPLES; THE SUPERHEAT TESTS ARE HERE GIVEN FOR PURPOSES OF COMPARISON ONLY.

ture as elements, the writer has consistently found the last the most difficult to represent satisfactorily.

It is a matter of considerable interest to know just what sort of thermal interactions are involved in the exact production of the curve $PV^n = C$ with a steam and water mixture. General relations cannot be expressed in serviceable shape, therefore it is necessary to resort to the solution of numerical examples. Taking typical conditions determined by test series V, Table 1, as

plotted in Fig. 26, the writer has calculated results which are presented graphically in Figs. 28 and 29.

The controlling conditions for this pair of examples are as follows:

General:		
Pressure at cut-off, lb. absolute		111
Corresponding steam temperature, deg. fahr		335.5
Piston displacement per revolution, cu. ft		3.10
Clearance, per cent		7.5
Particular:	Case *A*	Case *B*
Quality at cut-off, x_c	0.5667	0.7000
Exponent n	0.92	1.025
Weight of steam mixture, lb	0.2375	0.6332

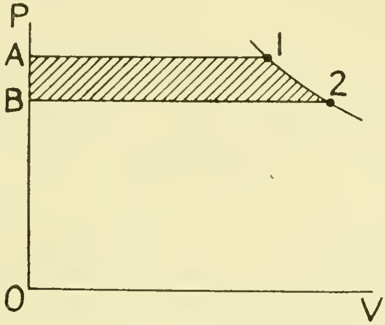

Fig. 27 Diagram Showing Method of Calculating Results in Figs. 28 and 29

Thermal quantities were first worked out for the weights of steam just named, then were reduced to b.t.u. per cu. ft. of piston displacement for use in the diagrams.

The method of calculation is illustrated by Fig. 27 and the relations involved are expressed by the equation

$$h_1 + q = A \int_1^2 vdp + h_2 \qquad [4]$$

Here h_1 and h_2 are heat contents or total heats at the beginning and end respectively of the expansion interval, or at points 1 and 2; q is the heat imparted to steam by cylinder walls; and

$$A \int_1^2 vdp = \frac{144n}{778(n-1)} (p_1v_1 - p_2v_2) \qquad [5]$$

is the heat equivalent of the work done in expansion from p_1 *to* p_2, represented by area $A12B$. The scheme is to use temperature intervals, of 15 deg., passing from t to p through the steam table.

In Fig. 28, distances from the base to line 1 represent heat used in the performance of external work, calculated by equation [5]. Distances from 1 to 2 represent changes $(h_2 - h_1)$ in heat content, positive in case A where h_2 is greater than h_1 ($n =$

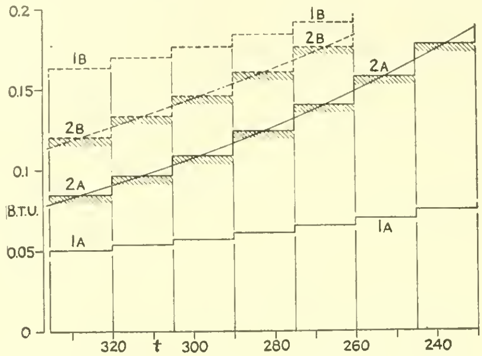

FIG. 28 RATES OF HEAT RECEPTION PER DEGREE OF CHANGE OF STEAM TEMPERATURE

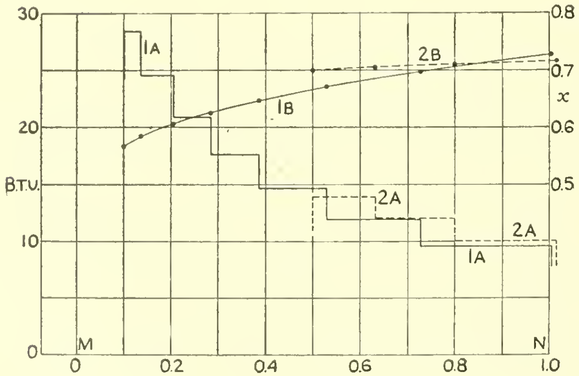

FIG. 29 RATES OF HEAT RECEPTION PER CUBIC FOOT OF PISTON DISPLACEMENT, ALSO CURVES OF STEAM QUALITY

0.92), negative in case B where h decreases with expansion ($n =$ 1.025). The net or resultant distance from base to line 2 shows heat received q.

Strictly, the areas beneath the several sections of the broken lines in Fig. 28 represent the heat quantities just named, while to the scale of the diagram the ordinates show rates of heat conversion, change, or transfer per degree of change of steam tem-

perature. Thus in case A, with 0.2375 lb. of steam, the heat added from 305 to 290 deg. is 5.05 b.t.u. This is divided by 3.10 to make it correspond with the steam in action per cubic foot of piston displacement and by 15 to make it heat per degree. In case B, with 0.6332 lb. of steam, the similar heat quantity is 6.76 b.t.u., to be reduced to the terms of the diagram by the same division. Because thus related to steam quantities other than 1 lb., the ordinates of curves 2A and 2B are not identical with specific heat; but they are proportional to unit heat capacity.

Of course, for this operation of hyperadiabatic expansion, the specific heats represented by curves 2 of Fig. 28 are negative. But the point of special interest here brought out is their increase with fall of temperature.

In Fig. 29 base MN represents 1 cu. ft. of piston displacement, with clearance OM added at the left; and it may also be taken to represent stroke of piston. The ordinate added is now, heat added divided by change of volume in expansion. Thus for the interval from 305 to 290 deg. in case A, heat q or 5.05 b.t.u. is divided by a volume change of 0.2417 cu. ft., and the quotient 20.9 is an ordinate of line 1A.

As bearing on the maintenance or production of a constant exponent n, we note that for case A, with early cut-off, a very rapid heat reception is required at first; but with later cut-off the requirement is more nearly uniform. Now the store of latent heat in the steam is relatively so large that a very small change in the manner of variation of quality x will set free or absorb quantities of heat which are of the same order of magnitude as those calculated for Fig. 28. We may therefore conclude that there is nothing in the showing of Fig. 29 to antagonize the empirical fact that for ordinary conditions of working n is practically constant. But we can see that for very early cut-off heat is likely to be less rapidly transferred at first than is required to produce the average value of n, while later the requirement may be exceeded. Such an action, with n at first large and pv decreasing, followed by decrease of n and increase of pv, is just what is observed in this case.

A few classic examples from our records are set forth in Fig. 30. The first two curves show the smooth form of the polytropic in the scheme of coördinates which is used. No. 3 is a case of very low speed, with rapid growth of pv at low pressure and accompanying decrease of n. No. 4 shows the opposite ex-

treme of high superheat, with fair approximation to a value of n considerably greater than unity. In the engine of No. 5 release was late, so that the expansion curve ran clear to the end of the stroke; and in this period of very slow piston movement there is time for a large inflow of heat, strengthened by jacket action. Curve 5 shows, then, condensation continuing past cut-off and very marked reëvaporation at the end of expansion. It

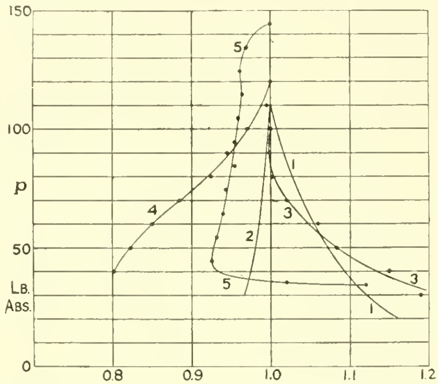

FIG. 30 PLOTS OF pv ON p, REFERRED TO THE INITIAL VALUE OF pv AT CUT-OFF AS UNITY

CURVES 1 AND 2, FROM EXAMPLES WORKED AND ILLUSTRATED IN FIGS. 28 AND 29 VALUES OF n=0.92 AND 1.025, RESPECTIVELY.

CURVE 3, TRANSACTIONS, VOL. 10, PAGE 742, FIG. 170, CYLINDER 17 IN. BY 30 IN., SATURATED STEAM, SPEED 8.64 R.P.M.

CURVE 4, TRANSACTIONS, VOL. 25, PAGE 267, CYLINDER 16 IN. BY 42 IN., SUPERHEAT 352 DEG. AT THROTTLE, 187 DEG. IN CYLINDER AT CUT-OFF, SPEED 103 R.P.M.

CURVE 5, TRANSACTIONS, VOL. 16, PAGE 176, LEAVITT PUMPING ENGINE AT LOUISVILLE, CYLINDER 27 IN. BY 120 IN., SATURATED STEAM, FULL JACKETS, SPEED 18.6 R.P.M.

is a striking example of how decidedly steam may fail to conform to the polytropic equation.

F. W. MARQUIS discussed the method of Mr. Clayton as a valuable aid in connection with the study of locomotive performance. It has heretofore not been possible to determine the steam consumption of locomotive engines under certain predetermined conditions of speed, cut-off, etc., by means of road tests, since in road service these conditions cannot be maintained constant for a long enough period to constitute a test. Mr. Clayton's method gives a way to determine the steam consumption under any conditions of speed, cut-off, etc., at which a locomotive can be oper-

ated, by means of indicator cards which can be taken while the locomotive is being used in regular road service, and a study of the effects of speed, cut-off, steam distribution, etc., can now be made by means of data obtained on the road tests. Further, from the logarithmic indicator diagram it is possible to determine accurately the times at which the different events of the stroke take place. This furnishes a comparatively simple method for determining the spring in locomotive valve gears. A study of this spring and its effect upon steam distribution, the stresses in valve gear parts, steam consumption, etc., with different types of valve gears, and under different conditions of running, is sure to prove of great value. The same method may also help to determine exactly why it is harder to make schedule time with passenger trains in cold weather than in warm.

Train resistance is greater in cool than in warm weather; a locomotive cannot make as much steam in cold weather, and again, steam must be furnished for heating the train. How much steam does it take to heat a train in cold weather? The steam thus used does not pass through the nozzle and help produce draft to burn the coal, as the steam used by the cylinders does. Is the amount large enough seriously to affect the steaming qualities of the locomotive? Information upon the above questions appears to be very meager, and has not in the past been easy to obtain. Now, however, it is possible to determine from indicator diagrams how much steam is used by the cylinders while the total steam used may be determined by means of tank measurements. The difference will be the steam used in heating and lighting the train, in running the air pump, etc.

Mr. Marquis called attention to the fact that the present paper includes data from only one locomotive test and said he understood that other data were to be given later.

C. D. Young. Good use has been made of the fact which has been established for some time that a practically constant quantity is obtained in the product of the absolute pressure by the nth power of the volume of steam under compression or expansion, the volume including the clearance space. This law has been well known mathematically as a straight line when expressed by its logarithmic equation, but Mr. Clayton has succeeded in defining what n stands for, showing that it is a quantity definitely related to the quality of the steam, and for any

given engine working under given conditions the value of n depends on the quality of the steam.

The writer assumed that this followed Mr. Clayton's discovery that the expansion and compression curves of indicator diagrams do as a general rule develop straight lines when absolute volumes are plotted against absolute pressures on logarithmic paper; and that where the plotted lines are not straight some defect in the cylinder is indicated and the amount of the discrepancy becomes an indication to some extent of the magnitude of the defect.

The writer feels that Mr. Clayton's discovery will develop to a point where it will be exceedingly valuable as a short-cut method and he is to be congratulated upon opening up a new field for study of cylinder performance of reciprocating engines. There are a number of statements in the paper, however, which he is inclined to question. For example, in Par. 8 is the broad statement that since working with the new method of analyses existing methods have been found to be in a very crude state and many deductions from them are without foundation or meaning. He finds nothing in Mr. Clayton's paper to substantiate such a statement and would hesitate broadly to criticize the past work on engine performance and deductions which have been made in that light of results developed by Mr. Clayton.

Again in Par. 11 statements are made to the effect that facts as set forth were unknown previous to this method of investigation; where as a matter of fact the writer believes that all the statements have been confirmed by work of others on this same subject.

The statement hardly seems warranted in Par. 74*e*, in which Mr. Clayton says that this method is more accurate than the average test, and is the only accurate method available for testing certain classes of engines. Assuming that the cards have been taken correctly and represent the actual cylinder performance, and before it is definitely determined what the actual water rate of cylinder is, the steam, either entering or leaving the cylinder should be measured by such means as are now available.

From the data obtained in Mr. Clayton's tests it is quite evident that the quality of steam mixture at cut-off when using superheated steam is in a large number of cases below the condition of dry and saturated steam and in Table 2, column 13, the quality of steam is given as below unity. The writer hesi-

tates to criticize this figure, although he possesses data which would indicate that the quality at cut-off as given by him for superheated steam will not be as low as that which he has given and obtained graphically.

Until Mr. Clayton's method can be checked against some of the accurate tests which are daily being conducted at Pennsylvania Railroad Company's Locomotive Testing Plant at Altoona, where all conditions can be controlled and accurate measurements taken, the writer hesitates to suggest further errors in the data as presented.

J. B. Stanwood. This paper is a good example of what an advanced scientific treatment of a well-known subject may develop. While the logarithmic treatment of expansion curves is not new,[1] the author has discovered that a relation exists of a very simple character between the quality of steam at cut-off in a steam engine and the expansion curve which develops from this quality of steam. This is an interesting fact which may prove of considerable value in further analysis of the action of steam in the cylinders of reciprocating engines.

In regard to the actual deductions made Mr. Stanwood calls attention to the fact that Mr. Clayton's deductions are based almost entirely upon experiments made with a 12 by 24-in. Corliss engine, and believes that the applicability of his method to the determination of the actual values of initial quality of the steam can be determined only after comparing a number of experiments of the same character on different sizes of engines. In the instance at hand, leaving leakage out of account, it would seem that the initial quality of steam at cut-off is dependent upon two things: the amount of steam actually condensed up to cut-off, and the quality of steam in the clearance space just before the admission. If the quality is based simply on the difference between steam as accounted for by the indicator at cut-off, and the water consumption as determined by the amount condensed in the condenser, he fears the result is not correct, as no consideration has been taken of the quality of the "cushion" steam. It may be possible that the quality of cushion steam may be as low as 10 per cent, especially if Mr. Willan's

[1] See Prof. Perry in the discussion of Mr. Willans' paper on Non-Condensing Engine Trials; Proceedings of the Institute of Civil Engineers of Great Britain, vol. 43, 1888.

theory is true that water retained on the clearance surface forms an important factor in creating cylinder condensation. Professor Zenner has stated that if he knew absolutely the quality of steam at any point during the compression he could determine the steam consumption of a steam engine from its indicator card (leakage being neglected). This question of the quality of cushion steam may have something to do with the variations in the results obtained by Mr. Clayton in his comparison of different engines, as shown in Table 4.

There are probably few, if any, engines operating without leakage and the writer thinks there must have been quite an appreciable amount in the 12-in. by 30-in. engine tested by Mr. Clayton. For instance, in Table 1, with 109 lb. absolute pressure at the throttle and 25 per cent cut-off, this engine is stated to have a quality of steam of 58.8 per cent. This means a cylinder condensation of 41.2 per cent, which is high for this cut-off in comparison with most tests that have been made on Corliss engines. George H. Barrus in his book on Steam Engine Tests gives the result of his experience with these engines and he estimates as a result that the amount of condensation for 25 per cent cut-off is on an average about 24 per cent. If therefore there was no excessive leakage in this engine, then these experiments show a remarkable difference between condensation in small engines and condensation in larger engines of the same general type. In Table 4 there is recorded a test (Analysis No. 107) of a 16-in. by 42-in. Corliss engine, in which the quality of steam is 77.4 per cent. In the same table, with a Corliss cylinder 23 in. by 60 in., the quality of steam is 76.7 per cent. The writer suspects that these engines were among those tested by Mr. Barrus in his work entitled Steam Engine Tests, and if so, the cut-offs were about 25 to 30 per cent. Is there this difference between engines of 12 in. and 16 in. and 23 in. bore? If not, there must have been some other cause which would make the quality of steam so low in the 12-in. by 24-in. engine and the writer suspects that it is leakage.

The discovery of Mr. Clayton may lead to the solution of some problems heretofore unsolved, such as determination of the actual quality of steam in the compression spaces; prediction of steam consumption, especially as influenced by the size of cylinders; effect of clearance and clearance spaces on the economy of the steam engines. Designers may also be able to improve the

proportion and construction of steam cylinders and valve gears by the character of the expansion curve under different conditions analyzed by this logarithmic method. The writer fears that a determination of the steam consumption of many types of engines by this method would not be very reliable. There are so many cylinders in which the steam is short circuited directly from the steam side of the cylinder to the exhaust side of the cylinder that no evidence of this loss appears on the diagrams, so that the use of Mr. Clayton's method would not be at all satisfactory. There are many single valve engines with balanced valves in use in this country in which the leakage begins to increase from the day they go into service; any diagram taken from them without absolute knowledge of the valve conditions would be useless, and we would caution engineers as to the unreliability of this method for engines of this class. When valves are made tight and can be kept tight, the investigation along these lines may be helpful.

William D. Ennis was able in one or two instances to verify Mr. Clayton's law. A small automatic engine gave $n=0.96$, with a dryness at cut-off of 0.62. A Corliss engine gave $n=1.02$ average corresponding with an indicated steam rate of 26 lb. per i.h.p.-hr., noncondensing. A study of values of n for the compression curve is interesting. Values exceeding 1.0 have repeatedly been found, along with such absence of high final temperatures as demonstrates that the customary Hirn assumption of initial dryness equal to 1.0 must be incorrect. Professor Ennis has found in two cases, with small automatic engines, n for compression$=1.85$ and 1.80 and in another instance it was apparently around 4.0.

From the thermodynamic side, the paper is of particular importance from the new light it throws on the question of heat interchange. Textbooks state that during the early part of expansion the steam continues to give up heat to the cylinder walls: afterward, as its temperature falls, again receiving this heat. But if the expansion line of the steam diagram conforms to the polytropic $PV^n=C$ there can be no such reversed transfer: the steam must be either steadily gaining or steadily losing heat. And, according to Mr. Clayton, it loses or gains according as it is dry or wet at the point of cut-off. In the light of the present paper, Professor Ennis is inclined to think that

the apparent reversal of transfer has been generally due to leakage. In the Callendar and Nicholson experiments the steam temperature dropped to that of the metal of the cylinder head in 1/18 sec. after cut-off. Considering the lag and dampening of wall temperature fluctuations, the conditions thus favor a gain of heat by the steam practically throughout expansion. Strangely enough, also, the wall temperature taken at a point in the side wall just inside the face of the head, began to fall while the walls were about 17 deg. fahr. cooler than the steam.

The subject of steam leakage is one of the most important which the paper suggests. The diagram attached is so clearly like some of those embodied in the paper in its indication of leakage that it is worth including for its confirmatory value. Leakage between two chambers will, other factors being constant, be proportional to the pressure difference and inversely proportional to the seal of the valve. The diagram sketches these variables and shows that leakage is most likely to occur:

a through the *steam* valve, just after cut-off, or just before admission

b through the *exhaust* valve, during the early part of a stroke

c through the *piston*, during the early part of a stroke.

In cases (*b*) and (*c*) the diagrams are scarcely likely to show leakage until after cut-off has occurred. Leakage through the steam valve, occurring just after cut-off, may be shown by a steam chest diagram. It raises the expansion curve during the early part of expansion. When it ceases, the true polytropic curve begins. Pre-admission leakage at this point raises the compression curve, and may take place at such a rate as to give a curve apparently polytropic, with an extremely high n value. A steam chest diagram may confirm the diagnosis. Leakage through either piston or exhaust valve, occurring just after cut-off, *depresses* the expansion curve. If it is the piston that leaks, a corresponding *rise* of pressure may in some cases be noted on the exhaust line of the compression diagram for the other end of the cylinder. If such leakage occurs before cut-off, the diagram in question will not show it, but the companion diagram may show a rapid rise of pressure during the early part of its exhaust period. Mr. Clayton's paper is thus far but a beginning. The bearing of the new law on the application of Hirn's analysis and the temperature-entropy diagram to actual tests will com-

pel us to revise our judgment as to the utility of these forms of investigation. A new and undoubtedly fruitful field has been opened in steam engineering.

Forrest E. Cardullo. It has long been known that the expansion of the working fluid in practically all reciprocating engines approximates the law $PV^n = C$, in which P is the absolute pressure, V is the absolute volume of the working fluid, and C is a constant. The paper before us proposes a most interesting method of cylinder analysis which takes advantage of this fact.

With that part of the paper which deals with the analysis of gas engines, air compressors and other reciprocating engines employing permanent gases, the writer is in complete accord. There are, however, many points in connection with that portion of the paper which deals with steam engines, with which he cannot agree.

One of the first questions which arises in this connection is how closely does the expression $PV^n = C$, represent the actual facts in the case. Taking the adiabatic expansion of steam and plotting the relation between the pressure and the volume on logarithmic paper, we find that the expansion curve is convex toward the origin, but that the curvature is so very slight as hardly to be noticeable. When plotted to the scale which Mr. Clayton uses and for the range in pressures employed in reciprocating engines, the adiabatic expansion line is sensibly straight.

In Par. 164, Mr. Clayton states that the only irregularities observed in the compression lines of steam cards occur with low speed, and are in the form of a "hook" which occurs at the point where the saturation temperature of the cushion steam rises above the temperature of the cylinder walls. The writer has seen such hooks due to cylinder condensation, in the compression curves of cards from a 7 by 12 straight line engine running at 300 r.p.m. These hooks will always occur with any type of engine when the compression is sufficiently great. They are more pronounced in engines having a small clearance volume, and the higher the rotational speed of the engine the higher the compression pressure at which they occur.

During the expansion the steam is condensed at the beginning of the expansion line unless the drop in pressure during admission is so great that the saturation temperature of the steam falls below the temperature of the walls before expansion commences. Later on, instead of condensation there is re-evaporation during the ex-

pansion period. If the adiabatic line is straight on the logarithmic plane, it follows that the actual expansion line cannot be, but will have a decided bend in it at the point where the saturation temperature of the steam is equal to that of the cylinder walls.

This effect is well shown in the temperature-entropy diagram of many steam engines which has the form shown in Fig. 31. In this figure, at the point marked A, the expansion curve is tangent to the adiabatic, and this is the point where the temperature of the steam becomes equal to the temperature of the cylinder walls. The temperature of the cylinder walls rises with the speed of the engine and consequently the bend in the logarithmic expansion curve will rise, until in the case of many high-speed engines it may be higher than

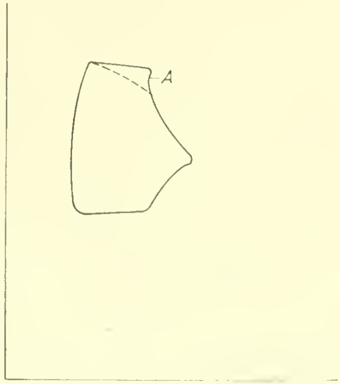

Fig. 31 Temperature-Entropy Diagram Showing Form of Expansion Line

the actual expansion line, which would be the case in Fig. 31 if the steam line was the dotted line instead of the full line.

The appearance of this bend is exactly the same as the appearance which Mr. Clayton attributes to leakage, and it may be questioned therefore whether leakage always exists when the expansion line has the form shown in Fig. 13-b.

In the case of a fluid expanding in a conducting cylinder, n is never a constant, but is a variable, although the variation is usually very slight and nearly uniform. Any appreciable irregularity in the logarithmic expansion or compression line is therefore evidence of leakage or of some other disturbing condition. We may therefore expect that a further study of the logarithmic expansion and compression lines will make clear some very interesting facts in connection with reciprocating engines.

Par. 42 states that the skin surface of the cylinder must be heated once every cycle from the temperature acquired by contact with the exhaust steam nearly up to the temperature of the admission steam. This statement is misleading since the range in temperature of the metallic surface is known to be comparatively small, being only from a fifth or a tenth of the range of the temperature of the steam.

From Par. 47 it is inferred that the phenomena occurring after cut-off are independent of the form of the cylinder and the relation between the volume and the clearance surface. The writer cannot believe that this is quite true. By changing the quality of steam, the volume, the clearance surface and the speed, there may be several engines having the same quality of steam at cut-off, but in which the rate of radiation of heat from cylinder walls into the steam will be quite different. Under the circumstances different values of n may be expected for the same quality of steam at cut-off. The mere fact that two or three engines of apparently dissimilar design give substantially similar values for n and X_c does not disprove the possibility of this variation, and until this point receives further attention, it cannot be taken for granted.

In Par. 64 it is stated that this method is the only one which measures the *rate* of steam consumption of an engine. A steam meter may be employed for the same purpose, and will probably be more accurate. In certain types of engines and with certain forms of indicators the error of the expansion line due to vibration will make the method very inaccurate. I do not believe that the method is sufficiently accurate to warrant its use in determining steam consumption, although it will probably be very useful in determining losses from leakage and in showing whether or not an engine is operating under the most economical conditions possible.

The method does not take account of leakage and if there is any the steam consumption obtained will be lower than the true steam consumption of some unknown amount. Since there are forms of leakage which will not show when the logarithmic analysis is employed, it follows that there will be cases when the steam consumption obtained by this method will be too low and yet there will be no evidence of the fact. On this account, while the steam consumption may be determined with reasonable accuracy in many cases, one can never be sure whether the method is accurate or not, and it must therefore always be looked upon with suspicion.

In connection with Par. 74, how does this method check with itself when the steam consumption of the high-pressure and low-

pressure cylinders of a compound engine are determined independently by its use? Does it give the same steam consumption for both cylinders as it should? In the same paragraph the writer would call attention to the fact that the method cannot be applied when the load on the engine is varying, since the temperature conditions of the cylinder walls are those acquired from a previous revolution, and the quality at cut-off and the form of the expansion line will be different from what it would be were the engine operating with the same cut-off under steady load.

In Par. 84 is given a graphical method of determining the clear-

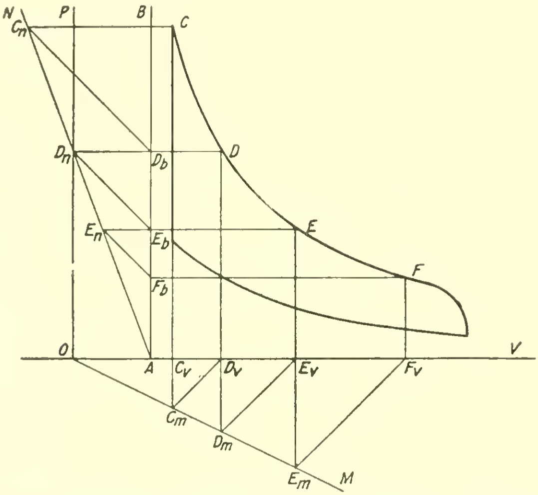

Fig. 32 Graphical Method for Determining Clearance

ance which is based on the assumption that the expansion line follows the law $PV^n = C$. The following is submitted as a preferable method:

In Fig. 32, CF is the expansion line of a gas engine card and OV the axis of zero absolute pressure. At any point A on this axis erect the perpendicular AB, and draw AN making any convenient angle to AB. Draw CC_n and draw C_nD_b making an angle of 45 deg. with AB. Through D_b draw D_nD and D_nE_b at 45 deg. Similarly, draw E_nE, E_nE_b, and F_bF. From F drop a perpendicular to OV and draw F_vE_n making an angle of 45 deg. with OV. From E_vD_m drop a perpendicular from D to determine D_m. Draw D_vC_m and drop a perpendicular from C to determine C_m. If the expansion line CF fulfils

the equation $PV^n = C$, C_mD_m and E_m will lie on the same straight line and that line will intersect OV at the point of zero volume. Erect OP at that point which is the origin of pressure and volume. This method [1] is more elegant, more accurate, and more simple than the method proposed in the paper.

There is no question but what the logarithmic analysis will show evidence of leakage in many cases. In certain cases, however, when there are simultaneous leaks of inlet and exhaust valves, it is quite possible that no leakage can be detected. This is also the case where the leakage takes place by the bodily transfer of water under the surface of a slide valve, which is the form of leakage most common in high-speed engines. There is no possibility of approximating the amount of leakage from the logarithmic diagram. Data in regard to the relation of the quality of the steam at cut-off and the exponent of expansion, obtained from engines equipped with valves known to be subject to leakage, should be regarded with suspicion.

It is a well-known fact that an engine which is apparently quite tight when standing, may have considerable leakage when it is running. So far as I can find from the paper, no attempt was made to determine the running leakage. It is unfortunate that Mr. Clayton did not check the quality of steam in the cylinder at cut-off by the thermoelectric methods employed by Callander and Nicholson. He did not state whether the engines tested have running leakage or not. It is desirable to have more evidence on this point, especially before using the method, for the purpose of determining the steam consumption.

If experience justifies the claims for this form of analysis, indicators which will draw the logarithmic diagrams directly upon the indicator card can be manufactured. The mathematical relations required are quite simple, and there ought to be no difficulty in constructing an accurate and simple apparatus for the purpose. Of course such an indicator will not draw correct diagrams unless the clearance of the engine has been determined and the apparatus adjusted accordingly. If, however, the indicator can be adjusted until the expansion lines are straight, it will be possible to use the apparatus without determining the clearance.

The Author. It is gratifying to find that the development of the new methods of analyzing cylinder performance described in the paper and the conclusions reached regarding them should

[1] For the proof see Practical Thermodynamics, McGraw-Hill Book Co., pp. 33 to 35.

be so generally admitted and approved, especially since these methods involve a most radical departure from the beliefs and teachings which have been held for the last fifty or sixty years.

The only serious objection which has been brought out is the effect of valve leakage, i.e., the leakage of steam through the valve in single-valve engines which does not enter the cylinder, on the method of determining steam consumption.

The relative importance of this objection resolves itself into the actual amount that this form of leakage assumes in practice and the relative size and number of single-valve engines in service as compared with the total horsepower of steam engines used in plants where the highest economy is essential.

The relations of the values of n and the quality of steam at cut-off, given in Fig. 6, are primarily applicable to engines of the general type of that tested, that is, Corliss or four-valve engines in which all the steam passes through the cylinder.

The elimination of valve leakage was the motive which led to the use of a Corliss engine to determine the constants given, as explained in Par. 14. It is obvious that any steam lost by valve leakage has no effect upon the diagram and therefore cannot be accounted for. The importance of leakage of any kind in affecting the results of the steam consumption method is fully pointed out in Par. 67, 69, 73 and 74.

The steam consumption method is however a direct means of measuring valve leakage, since the steam and water present in the cylinder may be accurately accounted for. This method has since been used with a high degree of accuracy in connection with the measurement of boiler-feed to measure the valve leakage of a locomotive engine.

The single-valve engine is not an important factor in large steam engine plants where power must be produced at the lowest possible expenditure of steam. It is used more generally in installations where its low first cost is important and where its high steam consumption is not objectionable, as in small isolated plants having need of all exhaust steam for heating, in auxiliary machinery, and also in locomotives and marine engines because their service conditions demand the simplest possible type of engine. However the valves employed in locomotives and marine engines usually leak very little steam, measured as the proportion of the total amount used, on account of the high speed

of the engine giving large specific capacity for the size of the valve, and also because the large size of the valve enables a very close fit to be made.

The greatest field for the steam consumption method will be found in plants where the highest steam economy is essential, or where tests are impracticable due to service conditions, and in this field the small single-valve engine is relatively unimportant.

The engine tested by Mr. George Mitchell and quoted by Mr. Stevens was only 6 in. by 6 in. in size. The 80-h.p. engine tested by Mr. Stevens has a cylinder probably not larger than 12 in. by 12 in. in size. It is only in the very small single-valve engines, which are unimportant from a power standpoint, that valve leakage reaches the value of 20 per cent, a figure Mr. Stevens uses as an average for single-valve engines. Even small single-valve engines may have very little valve leakage as will be seen from the three examples of this type of engine given in Table 4. The two smaller engines, 14½ in. by 13 in. in size, were tested by Mr. George H. Barrus, and the test results together with the diagrams were taken from his book, Steam Engine Tests. The average difference of the steam consumption for these three engines, as determined from the diagram and the test consumption, is 7 per cent, all of them being within the 8 per cent given in the paper.

Mr. Stevens' estimate of the average amount of valve leakage shows that he has totally neglected to take into account the most important type of single-valve engine, the steam locomotive. It is absolutely impossible for the valves of locomotive engines to leak any considerable amount and still obtain the high steam economy which is found on test plants. When a locomotive valve does leak as much as 20 per cent a loud steady "blow" is heard between exhausts.

The effect of leakage upon the application of the steam consumption method may be summed up as follows: If a properly taken indicator diagram is obtained from a noncondensing non-jacketed Corliss or four-valve engine, and if the logarithmic diagram shows that there is no serious leakage, the constants of Fig. 6 will give the steam consumption as stated in Par. 74. If however the same procedure is followed for a single-valve engine of the same type, the result depends upon the amount of valve leakage, but usually with a fair sized engine and the

valves in good condition, the steam consumption may be obtained from the diagram to within a maximum difference of 8 per cent of the test results, as shown in Table 4.

The results obtained by Mr. Rice in his applications of the method corroborate the figures given in the paper.

The variation of the n-X_c law with pressure mentioned by Mr. Moss has been verified further in work on locomotive engines. The distinction between different pressures rests upon the average coördinates of the points found at each pressure, although the average of all pressures gives results which are nearly as close.

Professor Heck's analysis of the heat transfer of series V of Table 1 corroborates the statement in the paper that n is a constant for ordinary conditions. The author has found, as Professor Heck mentions, that there is a tendency at very early cut-off for n to be high at first and then fall to a lower value. Curves No. 3 and 5 in Fig. 30 depart widely from the polytropic law due to the extremely low speed and probably also to steam-valve leakage during the latter part of expansion.

Mr. Marquis describes one of the broadest fields of usefulness for the new analysis, and shows that results may be obtained by its use which have not yet been obtained by means of present methods. A large number of locomotive tests have been analyzed since this paper was written.

Mr. Young questions the statement in Par. 8 concerning the usefulness of older methods of analysis. This statement is fully substantiated by the general results of the analysis. Previously no accurate method of obtaining the steam consumption from the diagram was in use, nor was any method known of determining leakage from the diagram with the engine in regular operation, and although several attempts had been made to determine leakage by the divergence of the expansion line from an equilateral hyperbola, yet the methods followed generally possessed no meaning and gave results of no value. The old method of obtaining the clearance of a steam diagram is fully explained in Par. 136, which shows its unreliability and that it is founded on wrong premises. No method of locating the cyclic events accurately was in use, especially for the events of a locomotive diagram.

The quality of the steam mixture at cut-off, called X_c, obtained

in the engine tested when using superheated steam, is below unity because the degree of superheat at the engine throttle was only from 50 deg. to 125 deg. fahr., and also because of the small 12 in. by 24 in. cylinder. Mr. Young probably has in mind locomotive cylinders of about 27 in. by 28 in., and degrees of superheat of from 200 to 250 deg. fahr. These conditions result in the steam being superheated about 50 to 90 deg. fahr. at cut-off.

The locomotive tests mentioned by Mr. Young have already been analyzed and the data will soon be available for use.

Mr. Stanwood questions the low values of X_0 obtained from the engine tested when saturated steam is used and compares them with the figures of Mr. Barrus for the same cut-off values of other engines. The engines mentioned by Mr. Barrus had cylinder displacements several times larger than the small engine tested, and the difference in the value of X_0 is due to small size which relatively increases the cylinder surface per cubic foot of displacement space. Mr. Stanwood is right in suspecting that some of these engines were tested by Mr. Barrus, in fact, about half of them were taken from his book, Steam Engine Tests.

The engine used was carefully tested for leakage by the usual standing tests and also by running the engine with steam on the crank end only, and taking off the cylinder head to observe piston leakage. It may be stated that valves and piston were practically tight when judged by these tests. The tightness of these parts was further demonstrated by the form of the logarithmic diagrams obtained from the engine, one of which is shown in Fig. 9.

Professor Ennis' high values of n for compression of steam are probably due to leakage from the steam chest into the cylinder at this point as he states in his discussion. Leakage through the steam valve however does not affect the early part of expansion, as stated by Professor Ennis, but only the latter part of expansion when there is considerable difference in pressure between the steam in the cylinder and that in the steam chest. This phase of leakage is treated in Par. 109, etc.

Professor Cardullo is correct in saying that the law $PV^n=C$ does not perfectly express the adiabatic expansion of steam. This law does express it however to within an average error of less than 1/5 of 1 per cent for saturated steam, as may be seen by referring to Bulletin No. 58, page 81, of the University of Illinois Engineering Experiment Station. However the question

as to whether the polytropic law $PV^n = C$ expresses the adiabatic expansion of steam has no direct bearing on the application of this law to the actual expansions occurring in practice.

The evidence gained from plotting over 1600 logarithmic diagrams from over 60 different engines using steam, air, gas and ammonia amply substantiates the statement that expansion and compression of elastic media obey the polytropic law except where certain exceptional conditions exist.

Professor Cardullo contends that since adiabatic expansion gives a straight line in the logarithmic diagram, it follows that the actual expansion cannot be straight. It must be remembered in this connection that theories are courses of thought which express the causes of facts, and that facts never conform to theories when these theories are incomplete and are based on wrong premises.

The present status of the actual forms of expansion curves in cylinders and the amount and direction of the heat transfer that has therefore taken place to give the curves is as follows: The facts gathered from 1600 examples prove that expansion and compression curves obey substantially the polytropic law under normal conditions of cylinder tightness, etc.; therefore it follows that any theories which lead to other conclusions are incomplete and are not supported by the facts, and hence these theories must be discarded or revised to express the facts.

The bend in the expansion line of Fig. 31 is the same as that caused by large leakage from the cylinder: tight engines do not give this abnormal effect.

Professor Cardullo's hypothesis concerning the relation between the volume and the clearance surface is fully answered by actual examples given in Table 4. Analysis Nos. 106 *a* and 110 are two examples which prove that, given the same values of X_c, the values of n which result are practically the same regardless of cylinder size or form and of engine speed. In this matter, as in the matter of polytropic expansion, facts take precedence over theories.

When steam meters are used to measure the rate of steam flow to reciprocating engines, the makers of this apparatus state that the calibration obtained with steady steam flow no longer holds for the intermittent flow of steam engines, and that these meters have to be recalibrated by an actual test for each individual location to give reliable readings.

The steam consumption of the high and low-pressure cylinders of compound engines check each other very well in work done since this paper was written.

The varying temperatures in a cylinder due to swinging loads do not alter seriously the accuracy of the steam consumption method.

The clearance method offered by Professor Cardullo is the reverse of the old method of constructing graphically a curve of the form $PV^n = C$. It is shorter than the logarithmic method, but it is neither as accurate nor as simple. It is not as accurate for the reasons given in Par. 90, nor as simple because the trigonometric relations used involve a higher degree of mathematical education than the mere selecting of the straight line position on the logarithmic diagram according to directions.

With regard to a further amplification of the analysis, suggested by several of the members who have discussed the paper, the purpose in writing the paper was to establish the broad principles of the analysis, and to give sufficient examples to show how these principles are applied and some of the results attained by their application.

STRENGTH OF STEEL TUBES, PIPES AND CYLINDERS UNDER INTERNAL FLUID PRESSURE

By Reid T. Stewart, Published in The Journal for April

ABSTRACT OF PAPER

A comparison of the theoretical formulae for the strength of steel tubes, pipes, and cylinders under internal fluid pressure shows that:

a Clavarino's formula is theoretically correct for cylinders with attached heads, and Birnie's formula for heads held independently. These formulae are practically applicable to certain classes of seamless steel tubes and cylinders and to critical examination of ordinary commercial steel tubes, pipes and cylinders when sufficiently accurate data are available.

b In commercial welded pipe the variation in thickness of wall, perfection of weld, etc., account for variation in bursting strength of sufficient magnitude to render unnecessary any consideration of Clavarino's or Birnie's condition of head support. All such variations give rise to errors on the side of danger when applying these formulae.

c For ordinary commercial wrought pipe Barlow's formula is to be preferred. This formula is

$$\frac{p}{f}=2\frac{t}{D};\ \ p=2f\frac{t}{D};\ \ t=\tfrac{1}{2}D\frac{p}{f};\ \ f=\tfrac{1}{2}D\frac{p}{t}$$

where D = outside diameter in in.

t = nominal or average thickness of wall in in.

p = internal fluid pressure in lb. per sq. in.

n = safety factor as based on ultimate strength

f = fiber stress in lb. per sq. in.

$= \frac{40{,}000}{n}$ for butt-welded steel pipe

$= \frac{50{,}000}{n}$ for lap-welded steel pipe

$= \frac{60{,}000}{n}$ for seamless steel tubes

$= \frac{28{,}000}{n}$ for wrought-iron pipe

The American Society of Mechanical Engineers, 29 West 39th Street, New York. All discussion is subject to revision.

DISCUSSION

C. M. Sames.[1] About four years ago the writer had occasion to make a considerable number of calculations on the strength of cylinders, and employed C. Bach's formula given in Des Ingenieurs Taschenbuch "Huette." This formula, adopting Professor Stewart's notation, is identical with Clavarino's, excepting that both numerator and denominator of the fraction under the radical sign are divided by ten. Inspection of a numerical table accompanying Bach's formula revealed the fact that it was possible to write an extremely simple expression that would give practically the same values. This expression is

$$t = \frac{0.42\, pD_2}{f-p}$$

and it yields results in no case deviating more than 1.4 per cent from those obtained by using Bach's (Clavarino's) formula for a range of $f=3p$ to $f=100p$. This formula was first published in the 1909 edition of an engineering handbook compiled by the writer. Inasmuch as the value (0.3) assumed for Poisson's ratio is at best an approximation, the simplified expression may be used with confidence where the Clavarino formula is called for.

The same expression may be used in place of the Birnie formula by substituting the numerical coefficient 0.495 for 0.42 when $f=10p$ to $100p$, and 0.483 when $f=3p$ to $10p$. In the first case the maximum deviation from the values obtained when using Birnie's formula is less than 1 per cent; in the second, less than 1.6 per cent.

The practical accuracy of this simplified formula may be shown by using it to solve Problem 2 in Professor Stewart's paper. Here it is required to determine the fiber stress f in the wall of a cylinder stressed both longitudinally and circumferentially, the outside diameter being 5.5 in., thickness $t=0.25$ in. (making $D_2=5$ in.), and $p=1500$ lb. per sq. in. Substituting these values in the simplified formula

$$0.25 = (0.42 \times 1500 \times 5) \div (f-1500)$$

from which $0.25\, f-375=3150$, and $f=14{,}200$ lb. per sq. in. Professor Stewart's method, using his table, gives $f=14{,}200$ lb.; using the Clavarino formula, $f=14{,}093$ lb. The discrepancy here is due to the fact that Professor Stewart used the nearest tabular value instead of interpolating.

[1] Editor, Industrial Engineering, New York

T. A. Marsh. Lamé's formula may perhaps be arranged in a more convenient form than that shown in Par. 17, as follows: Using the notations

S = Maximum allowable fiber stress per square inch
R = Outer radius of cylinder, in inches
r = Inner radius of cylinder, in inches
P = Working pressure within the cylinder
$T = R - r$ thickness of the cylinder wall, in inches

$$S = P\frac{R^2+r^2}{R^2-r^2} \qquad [11]$$

$$R = r\sqrt{\frac{S+P}{S-P}} \qquad [12]$$

$$r = R\sqrt{\frac{S-P}{S+P}} \qquad [13]$$

$$P = S\frac{R^2-r^2}{R^2+r^2} \qquad [14]$$

$$T = r\left(\sqrt{\frac{S+P}{S-P}}-1\right) \qquad [15]$$

$$\frac{R}{r} = \sqrt{\frac{S+P}{S-P}} \qquad [16]$$

Using equation [16] the writer at one time prepared Table 5 of ratios of outer to inner radii over a range of allowable stresses and working pressures such as are usually encountered in the design of hydraulic press cylinders.

In high-pressure work of the nature above referred to, it is evident that metals of low tensile strength have early limitations. Considering equation [16], it is evident that the ratio $\frac{R}{r}$ increases very rapidly as the working pressure approaches the allowable stress S. The ratio becomes infinite when $P = S$ and becomes an imaginary quantity when $P > S$. This means commercially that there is a limiting pressure beyond which it is impossible to design a safe cylinder, and a metal of higher tensile strength must be employed. The cost of materials will define the point beyond which it is economy to resort to better grades of metal.

Sanford A. Moss. For the two tests which Professor Stewart gives in Par. 31, and, in fact, for most cases of commercial tubes and

TABLE 5 RATIO OUTSIDE RADII TO INSIDE RADII, THICK CYLINDERS

Allowable Stress of Metal per Sq. In. Section, Lb.	Working Pressure in Cylinder, Lb. per Sq. In.												
	1000	1500	2000	2500	3000	3500	4000	4500	5000	5500	6000	6500	7000
2,000	1.732	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
2,500	1.527	2.000	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
3,000	1.414	1.732	2.236	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
3,500	1.341	1.581	1.915	2.449	.....	.....	.....	.....	.....	.....	.....	.....	.....
4,000	1.291	1.483	1.732	2.081	2.645	.....	.....	.....	.....	.....	.....	.....	.....
4,500	1.253	1.414	1.612	1.871	2.236	2.828	.....	.....	.....	.....	.....	.....	.....
5,000	1.224	1.362	1.527	1.732	2.000	2.380	3.000	.....	.....	.....	.....	.....	.....
5,500	1.201	1.322	1.464	1.633	1.844	2.121	2.516	3.162	.....	.....	.....		.....
6,000	1.183	1.291	1.414	1.558	1.732	1.949	2.236	2.645	3.316	.....	.....		.....
6,500	.....	1.264	1.374	1.500	1.617	1.825	2.049	2.345	2.768	3.464	.....		.....
7,000	.....	1.243	1.341	1.453	1.581	1.732	1.914	2.144	2.449	2.886	3.605		
7,500	.....	1.224	1.314	1.414	1.527	1.658	1.813	2.000	2.236	2.549	3.000	3.741	.....
8,000	.....	1.209	1.291	1.381	1.483	1.599	1.732	1.889	2.081	2.323	2.645	3.109	3.872
8,500	.....	1.194	1.271	1.354	1.446	1.548	1.666	1.802	1.963	2.160	2.408	2.738	3.214
9,000	.....	1.183	1.253	1.330	1.414	1.507	1.612	1.732	1.871	2.035	2.236	2.440	2.828
9,500	.....	.....	1.235	1.306	1.386	1.472	1.566	1.673	1.795	1.936	2.104	2.309	2.569
10,000	.....	.....	1.224	1.291	1.362	1.441	1.527	1.623	1.732	1.856	2.000	2.171	2.380
10,500	.....	.....	1.212	1.274	1.341	1.414	1.493	1.581	1.678	1.789	1.915	2.061	2.236
11,000	.....	.....	1.201	1.260	1.322	1.390	1.464	1.544	1.633	1.732	1.844	1.972	2.121
11,500	.....	.....	1.193	1.247	1.306	1.369	1.437	1.511	1.593	1.683	1.784	1.897	2.027
12,000	.....	.....	1.183	1.235	1.291	1.359	1.414	1.483	1.558	1.640	1.732	1.834	1.949
12,500	.....	.....	.....	1.224	1.277	1.333	1.393	1.457	1.527	1.603	1.687	1.779	1.878
13,000	.....	.....	.....	1.215	1.264	1.318	1.374	1.434	1.500	1.570	1.647	1.732	1.825
13,500	.....	.....	.....	1.206	1.253	1.303	1.357	1.414	1.475	1.541	1.612	1.690	1.775
14,000	.....	.....	.....	1.197	1.243	1.291	1.341	1.395	1.453	1.514	1.581	1.653	1.732
14,500	.....	.....	.....	1.189	1.233	1.279	1.327	1.378	1.432	1.490	1.553	1.620	1.693
15,000	.....	.....	.....	1.183	1.224	1.268	1.314	1.362	1.414	1.469	1.527	1.590	1.658
15,500	.....	.....	.....	1.177	1.216	1.258	1.304	1.348	1.397	1.449	1.504	1.563	1.627
16,000	.....	.....	.....	1.170	1.209	1.249	1.291	1.335	1.381	1.431	1.483	1.538	1.599

pipes, the ratio of wall thickness to outer diameter is so small that there is no appreciable difference between the various formulae mentioned. For such cases, say for $\frac{t}{D_1}$ up to about 0.03, Professor Stewart's use of Barlow's formula as being best for engineering purposes is undoubtedly justifiable for the reasons which he gives.

For the case of thick cylinders where the ratio $\frac{t}{D_1}$ has a large value there is a great deal to be said, however, in addition to the data which Professor Stewart gives. For such cases he seems to imply that Clavarino's or Birnie's formulae are proper ones to use for the respective cases with and without end heads. According to Guest's maximum shear law, which is now usually accepted, these formulae are considerably in error.

In any case in which there are stresses in two or three directions at once, some criterion must be known for computation, from the various stresses and strains, of an effective stress, which corresponds, so far as yielding is concerned, to the stress in a bar under simple tension in a testing machine.

The theory of elasticity as it has existed for years gives complete information regarding the computation of the stresses and strains, and the only matter of question is the criterion for the effective stress. In a thick cylinder subject to internal fluid pressure there is a tangential stress which is a maximum at the inner radius, and a radial stress. At the inner radius, the radial stress is equal to the pressure. If the cylinder has heads there is in addition an axial stress, due to the load of the pressure on the inner circle, uniformly distributed over the area given by the difference between the circles.

An old theory of the matter was the "maximum stress" theory. This stated that yielding would begin when the maximum stress in any direction reached the yield point for simple tension, regardless of the existence of the other stresses.

The Lamé formula, cited by Professor Stewart, correctly gives the maximum stress, which is the tangential stress at the inner diameter. Therefore, according to the maximum stress theory, it is the effective stress which must be considered in design work. This theory, however, seems to be wholly abandoned.

Another old theory is the "maximum strain" theory, and it is on this that Clavarino's and Birnie's formulae are based. This states that yielding begins when the strain or deformation in any direction,

due to the stress in that direction as well as to the lateral contraction due to stress or stresses at right angles, reaches the value corresponding to yielding due to simple tension.

The simple stress which would produce such a strain is called the true stress and is found by adding to the actual stress, called the apparent stress in this theory, three-tenths of any stress at right angles with proper signs. The factor 0.3 is the value taken for Poisson's ratio.

In a thick cylinder the maximum strain is the tangential strain at the inner diameter. The Birnie formula, which is the maximum strain formula for a thick cylinder without heads is, therefore, obtained by adding to the tangential stress given by the Lamé formula 0.3 of the internal pressure, which is the radial compressive stress.

The Clavarino formula is the maximum strain formula for the case of a cylinder with heads. The axial tension decreases the tangential strain so that the effective stress for a cylinder with heads is less than when there are no heads, according to the maximum strain theory. This is shown by the difference between the Birnie and Clavarino curves in Figs. 3 and 4.

The "maximum shear" theory originated by Guest in England and Mohr in Germany is now usually accepted by engineers who have investigated the matter. This states that yielding begins when the shearing stress reaches a certain value. Hence, when there are stresses in different directions it is necessary to compute that simple stress which produces an equal maximum shear. It can be shown that when there are two stresses with opposite signs the effective simple stress is the numerical sum of the two values. In the present case the maximum effective stress is at the inner diameter and is found by adding to the tangential tensile stress given by Lamé's formula, the radial compressive stress, given by the internal pressure.

The situation is the same whether there are heads or not, since the axial tension added by the heads is less than the tangential tension and makes no difference in the shear due to the tangential tension and radial compression. The equivalent stress thus computed is greater than that computed by Birnie's formula, since the whole radial stress is added instead of 0.3 of it. It is, of course, greater than Clavarino's formula, since nothing is subtracted on account of the axial tension caused by the heads.

Using Professor Stewart's notation, the effective stress as thus computed on the basis of the maximum shear theory is as follows:

$$\frac{P}{f}=2\frac{t}{D_1}\left(1-\frac{t}{D_1}\right)$$

This is the formula which the writer believes should be used for thick tubes and cylinders instead of the formulae cited by Professor Stewart.

It will be noted that this is the same as Barlow's formula, with the factor $\left(1-\frac{t}{D_1}\right)$, giving a decrease of safe pressure. This formula always gives values lower than the old formulae given by Professor Stewart. As stated, the result is the same with and without the heads, whereas the Clavarino formula gives an increase of safe pressure when there are heads.

PROBLEMS IN NATURAL GAS ENGINEERING

By Thos. R. Weymouth, Published in The Journal for May

ABSTRACT OF PAPER

In the production and transportation of natural gas many problems are encountered requiring special applications of engineering principles. It is the purpose of this paper to point out the most important of these and to outline the methods of solution. A brief discussion is given of the properties of natural gas, including a table of analyses of gases produced in the principal gas fields of the United States, together with a formula connecting the heating value of the natural gas with its specific gravity. This is followed by the development of the original formulae for the flow of gas in pipe lines, the power required for compression and the storage capacity of lines, and examples are worked out showing the general method of design of a transmission system.

DISCUSSION

C. N. Cross. There is one locality in the California oil fields which promises to become commercially important in the production of natural gas, viz., the Sunset-Midway district. A single well has for the past two years been producing sufficient gas to supply the entire city of Los Angeles.

That this statement is not an exaggeration will be more readily understood when it is known that the initial rock pressure of the gas in the field is often more than 2000 lb. per sq. in. When these gas pockets are first opened the string of tools is often thrown from the well and over the top of a 90-ft. derrick. Sometimes large quantities of sand and boulders weighing 15 to 20 lb. each are ejected from the mouth of the well. Under such conditions there are very lively times getting the well under control. For lack of transportation facilities this immense quantity of gas is largely being lost.

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TABLE 4 ANALYSES OF NATURAL GAS FROM THE CALIFORNIA OIL FIELDS. PER CENT BY VOLUME REDUCED TO 60 AND 29.82 IN. MERCURY

Location	Year	O_2	CO_2	(C_2H_4) (C_2H_6)	CH_4	N_2	Lower B.t.u. Junker Calorimeter	Lower B.t.u. by Analysis	Lower B.t.u. by Equation	Specific Gravity
Coalinga No. 1....	1911	....	19.20	....	79.0	1.8	667	709	754	0.7460
Coalinga No. 2....	1911	1.60	3.80	....	94.4	...	776	847	903	0.5974
Sunset No. 1......	1911	....	22.80	10.7	65.9	...	670	762	678	0.8217
Sunset No. 2......	1911	0.70	7.70	....	87.5	3.6	...	785	857	0 6434
Sunset No. 3......	1911	1.30	0.60	3.10	92.3	1.7	921	877	918	0.5824
Analyses made by Bureau of Mines and Published in Bureau of Mines Bulletin, No. 19. 1911										
Santa Maria.......	1909	0.2	15.5	20.2*	62.7	1.4	...	884	675	0.8254
Santa Maria.......	1909	0.2	14.1	19.0	64.6	2.1	...	882	709	0.7910
Torry............	1910	...	6.8	35.6	54.2	3.4	...	1053	695	0.8051
Coalinga...........	1910	...	11.1	....	88.0	0.9	...	789	836	0.6640
McKittrick........	1909	...	30.4	1.0	66.2	2.4	...	610	638	0.8616
West Los Angeles...	1909	0.1	1.0	2.7	91.0	5.2	...	859	902	0.5978
Sunset............	1909	...	10.5	....	87.7	1.8	...	787	838	0.6619
Fullerton..........	1909	...	1.7	9.5	86 7	2.1	...	929	876	0.6241
Fullerton..........	1909	...	1.4	10.9	85.8	1.9	...	944	873	0.6271
Kern River........	1909	...	6.5	8.0	84.3	1 2	...	884	841	0 6594

* The remainder of this column C_2H_6 only.

There was a trace of H_2 in Sunset No. 2, and of H_2S in Coalinga No. 1 and Sunset No. 1.

Noting the absence of California gases from Mr. Weymouth's table of analysis, the writer presents Table 4. The first five analyses were obtained in connection with the writer's work in the oil fields.

The sum total of the constituents of these five samples varies from 99.0 to 99.9 per cent. This irregularity is due to the fact that the measuring burette used could be read only to the nearest 0.2 per cent, and no attempt was made to determine the rarer gases. The percentage of nitrogen was read from the burette

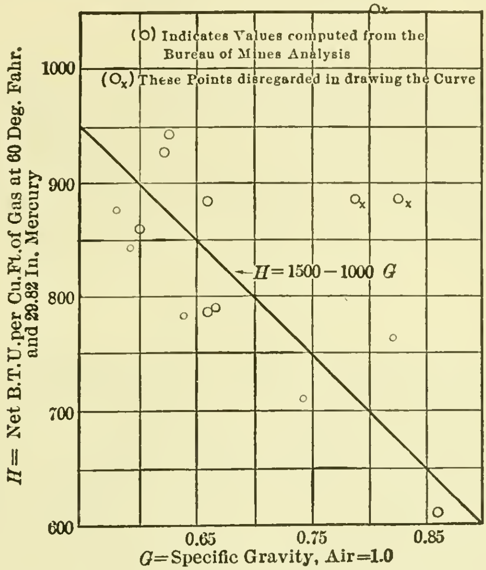

FIG. 14 RELATION OF CALORIFIC VALUE AND SPECIFIC GRAVITY FOR CALIFORNIA GASES

instead of subtracting the sum of the other gases from 100 per cent. The remaining ten samples were analyzed by the Bureau of Mines and published in the Bureau of Mines Bulletin, No. 19, 1911. In every case the total of these analyses is 100 per cent.

The peculiar feature of the California gases is the unaccountably high percentages of carbon dioxide present. The fact that California oils are of an asphaltic base may in some way be responsible for the large percentage of carbon dioxide. Roughly, the straight line law connecting the calorific value and the specific gravity, shown by Mr. Weymouth, holds for these gases, but the slope of the line, Fig. 14, is reversed due to the presence of the carbon dioxide in large proportions.

BITUMINOUS COAL PRODUCERS FOR POWER

By C. M. Garland, Published in The Journal for June

ABSTRACT OF PAPER

The paper describes the apparatus and general arrangement of bituminous coal producers as designed for power. The scrubbing apparatus is described in detail, data given on its efficiency, and the amount of solid matter delivered in the gas. Data on the efficiency of the plant, composition of the gas, and operating costs, together with brief discussions on these items are also included. Figures for the first cost and operating costs at full load for a 1200-b.h.p. plant are given in such a way as to make them applicable to different conditions of fuel and load.

DISCUSSION

O. P. Hood expressed the desire to have in this country some way of using very low grade, very high ash fuel. Coal is too cheap now to bring that into immediate use, but that source of supply will doubtless be called upon in future. In looking over Mr. Garland's paper he noticed in the analyses of the coal a great proportion of CH_4. In some of the work at Pittsburgh, in reviewing that particular item, it was found that what has been credited as CH_4 was probably CO, and the analysis of gas which shows a considerable proportion of CH_4 is a little doubtful. The chemists ought to review a little their methods of determining this quantity.

E. D. Dreyfus asked if Mr. Garland in determining his efficiencies determined the power to drive the tar extractor, and how the samples of gas were taken, to which Mr. Garland replied that the figures given in the paper do not include the power for driving the tar extractor, but this power is stated to vary from 5 per cent of the b.h.p. of the n. The samples were usually taken

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over a period of about 30 minutes, and drawn through a calibrated meter.

T. A. Marsh asked why, with the published low cost of power from gas producers, public service corporations are buying steam plants. He said he would like to know what can be expected in the large power plant with a peak of 10,000 kw. or over, and when the small plant of say 1000 kw. can be expected to consider producers, say in New York, Pittsburgh, Cleveland and St. Louis.

E. D. Dreyfus stated in this connection that at the present prevailing price of fuel, a producer plant is commercially limited to sizes under 1000 kw.

C. W. Baker referred to a passage in Mr. Garland's paper in which it is said that with exhaust boilers for gases discharged from the gas engine, these gases should not be reduced in temperature below 220 deg. fahr.. unless a cast-iron boiler is used. Mr. Baker's impression is that these gases will produce no corrosion provided their temperature is not reduced below 212 deg., but if there is any sulphur at all in the fuel, even a cast-iron boiler will not stand it long. Within 24 hours Mr. Baker had seen a good solid block of steel that had been a piston rod eaten into a honeycombed mass.

SOME TESTS ON CARBURETERS

By George W. Munro, Published in The Journal for March

ABSTRACT OF PAPER

The paper outlines the problem of carburation for motor vehicle engines and points out the difficulties met in determining the performance of a carbureter as distinct from the performance of the engine to which it is attached.

Results of 400 economy tests on a single engine served by six different carbureters under identical conditions of speed and load are presented in graphical form. By these it is shown that the performance characteristics are different with the different carbureters and that the carbureter characteristics would be determined if those of the engine on which they are superposed were known. Approximate engine characteristics are developed for comparison by using the best performance obtained with any carbureter.

Attention is called to the economic importance of the carbureter, the desirability of applying more scientific methods in its development, and the necessity of having available a testing plant, the constants of which are well determined.

DISCUSSION

F. S. King stated that in his work, he has used gasifiers, as they give more satisfactory results on throttled governed engines, where close regulation is required. The cooling water from the engine water jacket is circulated round the air passages of the gasifier in which a portion of the air supply is carburetted by the gasolene.

This richly carburetted air is then mixed with diluting air in the proportion required for proper combustion. This method gives satisfactory results, even with low-grade oils, good results being obtained with oils as low as 50 deg. in engines with cylinders 11 in. bore or below. On larger cylinders, liquid fuels do not give as satisfactory results, especially in the lower grades, when used in connection with carbureters.

Mr. King emphasized the dependence of the carbureter ac-

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tion on that of the device to which it is attached, and found it particularly so when used with jump-spark ignition: the compressions vary with the load, and carburetors are blamed for the erratic action of varying load conditions which affect the jump-spark more than the carbureter. Mr. King also wished to know if anyone knew, or had any information as to whether the quality of gas in the California natural gas field was uniform from day to day. He had heard of cases where engines operated in a most satisfactory manner for long spaces of time, and without any change in adjustment of mixtures, or change in the quality of lubricating oil or the amount of oil used, an accumulation would take place in the cylinders, without any apparent reason. The ignition system was in first class condition.

F. H. Vose called attention to the fact that there are other difficulties besides those mentioned by Mr. Munro which should be kept in mind during the execution and analysis of carbureter tests. Thus the gasolene is an exceedingly complex fuel, and moreover the commercial product is somewhat variable to say the least, even when purchased through the same sources. Variations may therefore be due to different fuel characteristics, even though the specific gravity for all samples used be nearly identical. Further it seems somewhat doubtful if each carbureter under test receives the proper treatment when the operator depends entirely upon his general observation of the performance of the engine to achieve the best results. In determining the engine characteristics the manograph would prove of great value. It would show the behavior of the explosive mixtures in the engine cylinder, and also check off the behavior of one cylinder against the others: with certain carbureter adjustments the explosions, or "near explosions," will be found to vary widely in character, while other adjustments will give uniform results. The manograph is not advocated here as a means of determining the horsepower of automobile engines, but as an excellent assistant in studying the engine operation.

From certain observations in carbureter adjustments for road service it seems evident that adjustments made for maximum power while the engine is on the testing frame, or with dynamometers attached to the rear axle, do not give the best results on the road; particularly is this true in hill climbing tests. The dif-

ference noted in this characteristic may indicate a slight difference in other characteristics between the dynamometer tests and road service. In this connection the effect of atmospheric conditions upon carbureter action should not be lost sight of. The relative humidity of the air certainly has a marked effect upon the action of some carbureters.

The inlet manifold from the carbureter to the cylinders has an appreciable influence upon carbureter action, particularly on the behavior of the mixture in the different cylinders.

Geo. A. Orrok pointed out that in most or all of the carbureters Mr. Munro tested the automatic devices for supplying the excess air are of an early type, and most of the later ones have better arrangements for handling that. For a carbureter that must work under a variety of conditions, the auxiliary valve for the air is very important. In running motorboats humidities all the way down from 100 per cent to pretty dry air are obtained, and conditions have to be adjusted to suit the air to get full power out of the boat.

The Author. The author agrees with Professor Vose that a manograph, had one been available, would have been of material assistance in the work. As it was, the carbureter adjustments were made with the aid of an indicating tachometer and the prony brake, the aim being to carry the maximum load possible at 1200 r.p.m., and in case a variation of fuel consumption was possible under this condition, to adjust for best economy. This was the adjustment throughout the tests on this carbureter.

The carbureters used were all of widely advertised makes, furnished new by the makers especially for these tests. The same inlet manifold and ignition system were used throughout the work, eliminating these elements as variables so far as possible. As the work extended over a period of several weeks, there were of course atmospheric changes entirely beyond control.

The author regrets that the discussion did not touch on what he regards as the principal point of the paper, namely, that a carbureter, an important machine in power production, has essential characteristics which may be determined and plotted, and whether it is worth while to establish the proper facilities for making comprehensive carbureter tests.

NEW PROCESSES FOR CHILLING AND HARDENING CAST IRON

By Thomas D. West, Published in The Journal for June

ABSTRACT OF PAPER

This paper outlines a series of experiments to determine the effect of different methods of treatment in chilling or hardening cast iron during the process of cooling after pouring the mold.

The first experiments showing how to produce mechanically mottled and white iron inside a gray body led to experiments with chillers used in different ways; and with various other heat-absorbing or hardening media, such as air, charcoal, powdered manganese, cyanide, etc. A study was made of the effectiveness of chillers of different thicknesses and of different metals; of the effect of cooling chillers, etc.

The experiments indicate, among other results, that the accepted idea of chilling occurring entirely while the molten metal is solidifying is wrong; and they show how stronger grades of iron can be used for car wheels, rolls, etc., and still obtain the desired depths of chill in such castings. They also demonstrate the superiority of air cooling over metal chillers.

DISCUSSION

Henry M. Howe.[1] Mr. West found that, if after the outer part of a cast-iron casting has solidified and cooled at a normal rate to somewhat below its eutectic freezing point, thus becoming graphitic, the casting is suddenly withdrawn from the mold and quenched in water at a moment when the interior has already solidified, the inside will be of white iron. The fact that the inside of the casting is white, though the normal slow rate of cooling extended below the eutectic freezing point, shows that it solidified as white iron. Because the inside solidified as white iron, the outside evidently did also. The graphitization of the outside must have occurred in that phase of the

[1] Prof. of Metallurgy, Columbia University, New York.

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cooling by which the gray outside had outrun the white interior at the moment when the quenching occurred.

Because the amount by which the cooling of the outside outran that of the inside must have been very slight, the writer infers that this graphitization occurred in a very narrow range of cooling, and presumably below the eutectic freezing point. The reason why the inside remained white may be either (*a*) that it hurried through the temperature just below the eutectic freezing point too fast to allow its cementite to graphitize; or (*b*) that the graphitization was restrained by the pressure put on the interior by the rapid cooling and contraction of the exterior; or (*c*) both these causes may have coöperated. In this particular case his experiments showed that if the slow cooling had not been thus interrupted the interior would have been very gray.

Thus Mr. West confirmed in a very simple and effective way the evidence of Heyn and Bauer that graphitization chiefly occurs immediately below the eutectic freezing point.

The usual occurrence of white cores inside of gray iron pigs so often reported is probably due to pressure. If the outside of the casting becomes firm and rigid, the separation of graphite inside it immediately sets up pressure, because the graphite is so bulky, and the existence of this pressure tends to prevent the further formation of graphite in the parts further in. In most cases this tendency is resisted by the slower cooling of the interior than of the exterior, slow cooling in itself prolonging the opportunity for the graphitization of the cementite.

Thus there is a struggle between slower cooling in the interior which tends to bring the carbon to the state of graphite, and pressure in the interior which tends to prevent it from assuming the form of graphite. In the majority of cases the slower cooling has the mastery, and the interior of the casting is as graphitic as the outside, but in certain cases the effect of pressure has the mastery and restrains the formation of graphite in the interior of the casting. It may often happen that the throwing of a stream of water on the pigs after their outside has turned gray, but before the inside has, or their removal from the sand in cold weather at this point in their cooling, may, as in Mr. West's experiment, lead to an internal chill.

P. Munnoch.[1] It is interesting to find that the phenomenon of internal chill which has puzzled the foundry for so many years has been explained by Mr. West and found to be capable of reproduction. Although the internally chilled castings one sometimes meets in the foundry have not been produced by quenching in water, there is no doubt but that they are due to some rapid cooling effect just at the period when the metal in the center is susceptible to rapid cooling.

In reference to external chilling, the experiments of Mr. West have demonstrated that the chill structure is produced after the metal has solidified. This corroborates the work of E. A. Custer with castings made in chill molds which show no signs of chilled structure provided the castings are removed from the molds immediately after casting.

The placing of a chill in a mold no doubt has a great effect at the beginning of the chilling period, but as the temperature of the face of the chill block becomes heated the chilling effect is reduced considerably before the end of the chilling period, whereas the effect of air chilling will continue equally efficient during the whole of the chilling period. This no doubt accounts for the better results obtained with air cooling by Mr. West.

Paul Kreuzpointner.[2] Summing up the deductions to be drawn from the detailed results of the paper, there are several methods whereby we can obtain a chilled surface in cast iron, the depth of the chill depending upon three factors: (*a*) conductivity of the chilling medium, (*b*) continuity of contact of the chilling medium, and (*c*) quickness of action of the chilling medium, always provided the chemical composition is favorable to obtaining good results.

When chilling cast iron it is aimed to prevent the changing of the combined carbon into graphitic carbon. The interval of time when this change from combined carbon to graphitic carbon takes place being limited, the success of obtaining a satisfactorily chilled casting depends on the united efficiency of the above three factors; hence the importance of having the proper chilling medium.

If the conductivity of the chilling medium is poor, continuity

[1] American Shoe & Foundry Co., Mahwah, N. J.

[2] Secy. American Foundrymen's Association, Altoona, Pa.

of contact and quickness of action will not help much. The best conductive media will give inferior results if the contact is broken too soon or if it is applied too slowly. Of course through intensity of application of one of these three factors we may be able to modify, to a certain extent, the unfavorable influences in weakness of the other two factors, but then we enter the realm of chance and haphazard work.

Since the conductivity of a chilling medium is dependent upon its ability to carry away from the casting a maximum amount of heat in the shortest possible time it is obvious that if the chilling medium is a metallic substance, that metal ought to be as dense as possible in structure, because in such a metal there exists the closest contact between the particles, which in turn permits the heat to travel quickly through the mass of the particles or crystals. Therefore wrought iron would seem to be the least adapted to act as a chilling medium because of the presence of the cinder which acts as an obstruction to the rapid traveling of the heat from one particle to another. Theoretically tool steel would seem to be the best chilling medium of the metal class because of its freedom from interposing films of slag or graphite between the crystals, hence maximum conductivity. However, in every-day practice this is out of the question and it is only mentioned in connection with the question of conductivity of chilling media. Thus for every-day practical operations we have to fall back upon cast iron or a suitable stream of cold air, where this is feasible. In the end it is always the problem to convey the heat away from the casting quickly enough to prevent change of carbon from one state to the other in order to obtain a desired depth of chill.

James A. Beckett.[1] The immersion test referred to in Pars. 63 and 64, indicating the practicability of continuing chilling after the metal solidifies, brings out a new idea in connection with this subject and opens a new field for investigation.

Long experience has demonstrated that for surface chilling nothing better has been found, cost and wearing qualities considered, than the cast-iron chiller, which is also a fairly good absorber of heat, and holds its shape well.

Surface chilling is almost entirely a matter of heat transference, but the efficiency of any chilling medium may be increased

[1] Hoosick Falls, N. Y.

by the selection of a mixture of irons which have the tendency to a greater increase of combined carbon upon remelting than is found in ordinary foundry irons. Irons of a given analysis made from certain eastern ores have this tendency to a greater degree than most southern irons of the same analysis.

The experiment shown in Par. 29 to determine the effect of warm chillers is in accord with the results of practical experience of long standing. For many years, plow castings have been made by using the chiller for the cope of the mold, in the upper surface of which was formed a receptacle, and into this warm or hot water was poured just before the iron was poured into the mold. The effect of the heat was to reduce the depth of chill in the casting, and by securing uniformity in the temperature of the chiller, to produce a uniform density of grain in the fracture without materially decreasing the strength of the casting. In this way, castings were produced with a close grain and susceptible of a very high polish.

Surface chilling results from the instant withdrawal of heat from the surface of molten iron, and is only in a limited degree proportionate to the thickness of the chiller used, as shown in Par. 31. This is true because the body of the chiller, however thick, will not transfer the heat absorbed by the face of the chiller as rapidly as it is absorbed, hence the resort to water cooling and similar devices. The application of a jet of air to aid in the chilling process is a difficult matter, expensive in the long run, and not likely to come into use except in special cases.

Par. 65 contains a statement of two laws, the second of which is: " Graphitization having once taken place in the crust or body of a hot casting, no sudden cooling can restore the carbon to its original combined form. And only by remelting can it be so transformed as to have a chilled or white iron structure." This law is not as positive in its action as Mr. West assumes, except in the case of gray iron. White iron used in the malleable iron industry, when subsequently annealed until practically all its carbon is in the graphitic form, may be restored to its original state in which practically all its carbon is combined by heating it to a cherry red and quenching it in cold water.

Carl Hering.[1] This paper is a good illustration of the importance of studying more carefully the phenomenon of the flow

[1] Cons. Elec. Engr., 929 Chestnut St., Philadelphia, Pa.

of heat through bodies and to other bodies. Like an electric current, a flow of heat encounters a resistance which opposes or checks it more or less, hence when the flow should be rapid, as in the chilling of a casting, this resistance to its flow should be kept as small as possible. The thermal resistance of the cast metal itself is a physical property of the material and is therefore beyond control, but the resistance between it and the chilling material can be controlled, and it is this resistance which is probably so much greater than all the others that it virtually governs the flow of the heat.

The thermal resistance of a joint between two solid bodies, that is, at the surface of a mechanical (not soldered) contact, seems to be relatively very high. This was shown in the case of fire brick in the experiment quoted by the author in Par. 45 and Fig. 15 from an article of the writer's. But with metals this resistance seems to be relatively far greater, as is shown by the fact that an iron bar with a transverse crack part way through it near its end will, when that end is heated to redness, become red up to the crack, while it is still black on the other side. This shows that the heat in flowing to the cold end meets with a very high thermal resistance at the crack, even though it may be only an exceedingly thin one.

In chilling a casting like a car wheel with an iron chiller the heat must traverse the surface of contact and as the cast metal shrinks and the chiller expands, an actual separation must occur, and the very high thermal resistance introduced thereby will no doubt govern the flow of heat and reduce it greatly. This is shown by Mr. West's experiments in which he obtained a better flow of heat when he applied a pressure between the metal chiller and the shrinking casting. It is evident, however, that such a pressure contact cannot possibly be made between two cylindrical surfaces, as in casting car wheels.

Another and sometimes extremely high thermal resistance exists between a metal and gas.[1] A thin layer of very high resistance seems to be produced on the immediate surface. This is what limits the rate of the flow of heat from the flames to the water tubes of a steam boiler. A postage stamp pasted on the outside of a tin cup in which water is boiled over a flame will not char, showing an enormous drop of temperature through a

[1] Flow of Heat Through Contact Surfaces, Met. & Chem. Engrg., January, 1912, p. 40.

layer of only a few thousandths of an inch in thickness, which is merely another way of stating that this layer has an extremely high thermal resistance.

This high surface resistance can be destroyed mechanically by carrying away this film of gas, and this is what Mr. West seems to have accomplished by chilling by means of a rapid flow of air in immediate contact with the metal. His results seem to confirm this theory, or if the theory is acknowledged to be correct, his method of air chilling is a rational one, since it enables him to destroy this high contact resistance, which it would be difficult to do in practice between two metallic surfaces, and apparently would be quite impossible when the surfaces are cylindrical as in the case of car wheels.

Another advantage in cooling with rapidly flowing air is that it affords a possibility of controlling the flow of heat from the casting, hence also the depth of chill and its uniformity in successive castings. This would not be easy with metal chillers. Moreover iron chillers are likely to be in actual, good, compressed contact at only a few points, and as the thermal resistance at those points would be considerably lower than at the rest of the surface it is likely that the chilling would be greater at those points, hence not uniform.

A. S. Dowler [1] said in a communication that in his many years' experience in the wheel business he had read many articles on processes of chilling and controlling the chill, but none which mastered the subject so completely as this paper. A method which can increase the depth of chilling after a crust has commenced to expand away from the chiller should permit the use of softer and often stronger grades of iron than are ordinarily permissible in the manufacture of car wheels. Present methods demand a high-chilling iron in order to obtain the desired depth of chill, which, as a rule, is an iron likely to give trouble because of its bordering too closely on a chilled or white structure.

Albert Sauveur.[2] Mr. West's statement to the effect that the chilling of cast iron does not occur entirely while the molten iron is solidifying is undoubtedly true, but the writer thinks that the opposite view is not the accepted idea. That chilling may continue after solidification is not only consistent with what we now

[1] St. Louis Car Wheel Company, St. Louis, Mo.

[2] Prof. of Metallurgy and Metallography, Harvard Univ., Cambridge, Mass.

understand to be the mechanism of that phenomenon but is demanded by it. By the chilling of cast iron is meant the retention of its carbon in the combined condition, that is, as the iron-carbide Fe_3C or cementite. This carbide must be prevented from dissociating, that is, from breaking up into iron and graphite ($Fe_3C = 3\ Fe + C$), or, in other words, its "graphitizing" must not be permitted. Cementite, however, represents an unstable condition of carbon while graphite is the stable form of that element. The tendency on the part of cementite to dissociate is the greater the higher the temperature. It is, therefore, maximum during solidification immediately after its formation, but it does not by any means cease once the cast iron has become solid. Indeed it is well known that cementite may be readily decomposed at a temperature as low as 800 deg. cent., that is, some 350 deg. lower than the solidification point of cast iron. To illustrate, cast iron may easily be conceived to solidify so quickly that its carbon is retained entirely in the combined condition, but to cool so slowly afterwards that most, if not all, the carbon passes to the graphitic condition. Clearly the chilling due to rapid solidification was entirely obliterated by subsequent slow cooling. That the chilling, therefore, may continue long after solidification is indeed to be expected.

Bradley Stoughton. Mr. West has again put the foundry industry under obligation for his elucidation of the operation of the chilling of cast iron. It may confidently be expected that his investigations will result in improving the quality of chilled car wheels, cast-iron rolls, plows and other objects made of chilled cast iron.

In two respects the writer must differ with the author of the paper: first, with regard to his statement in Par. 65, "Graphitization having once taken place in the crust or body of a hot casting, no sudden cooling can restore the carbon to its original combined form, and only by remelting can it be so transformed as to have a chilled or white iron structure." While this statement is no doubt correct under the conditions of his experiments, and in the sense in which he probably intended it, it cannot properly stand in the terms used in his paper, in view of the positive results of G. B. Upton[1] to the contrary, and, in a minor degree, in view of the well-known whitening of some gray and

[1] The Journal of Physical Chemistry, October 1908, vol. 12.

annealed cast irons when they are reheated to temperatures far below their melting point and plunged into water. That is to say, reheating and plunging into water may accomplish what mere plunging into water from a high temperature during cooling after solidification will not accomplish, and what Mr. West says can be accomplished only by remelting.

The writer's second difference relates to the author's statement that it is an accepted idea that chilling occurs entirely while the molten metal is solidifying. It may be an accepted idea among foundrymen who are not familiar with experiments of others in this field, but it has been known and published by more than one observer that chilling may be effected by rapid cooling subsequent to solidification. This correction does not in any way disparage the value of Mr. West's work; on the contrary, the accuracy of his experiments is further confirmed by the fact that they have corroborated the work of others without any previous prejudice in that direction on the part of the investigator.

J. E. Johnson, Jr., said that at the Ashland plant of the Lake Superior Iron & Chemical Co., of which he was manager, they had been conducting a research for a year and a half past on the general subject of the quality of the iron, and particularly on the subject of iron with an internal chill. In charcoal iron and also in coke iron they sometimes found a spot the size of a nickel, chilled perfectly white, in the center of a pig which was perfectly gray on the outside. They do not know the cause, but believe it to be the result of segregation. Analysis showed ½ per cent more carbon in the gray exterior than in the chilled center, but this result has not been confirmed in all cases. The current explanation among scientific people that the central portion is prevented from expanding (which must occur when the graphite is evolved), by previous solidification of the crust around it, is not valid as they see it, because all irons are cooled under these conditions, and if one shows an internal chill all should.

They have found that these irons are embraced in what are known as high cleavage irons, which means in plain English, rotten irons of very low strength. This character follows the iron throughout, and in a remelt will show up about the same as in the original iron. Even two or three remeltings will not alter the character of the iron unless something radical is done

to change its nature. It will still be spotted iron. As a result, his company never ship this iron to any user who does not alter the fundamental character of the iron before putting it into service.

Their researches have reached the place where they are certain there is virtually no relation between the fundamental quality of the iron and its composition as determined by analysis. There is a certain relation between the percentage of silicon and its chilling quality, but beyond that, with regard to its fundamental characteristics, such as strength, hardness, endurance, etc., an analysis for all the ordinary elements, including carbon, gives no reliable indication. Physical tests, the fracture of the iron, the surface of the pig, its grain and other points must all be considered at least as much as chemical analysis. Even the microscope does not give results that can be depended upon absolutely. His company has been making microscopic examinations of the various irons that they could obtain for over a year, and no relation between the microstructure and the physical qualities has been discovered that they could tie to.

To illustrate the utter unreliability of chemical analysis, Mr. Johnson quoted the records of two cases which were practically identical in all elements, including carbon. With every cast are poured 1¼-in. round test bars. The bars from one of these casts broke at an average of 2725 lb. and those from the other at 4950 lb., or nearly double as much.

The chilled car wheel is bound to be used for years to come and the subject of chilling irons is of enormous importance. Probably 95 per cent of all the freight traffic of the country is carried on on chilled cast iron car wheels. The steel wheel has not, by any means, fulfilled the promise of its advent. The problem is to make the chilled cast iron car wheel good, and the writer believed that could be done by the use of charcoal iron and by that only. He had definite and positive knowledge of one foundry, operated by a railroad, under the care of a man who knows his business, where they make wheels for their own use exclusively. Instead of buying junk and treating it with ferro-manganese and other medicines, he buys selected brands of charcoal iron, all tested under his own supervision for their strength and chilling qualities. As a result, he gets a life for his wheels, in service, on one of the great trunk lines of the country,

of 95,000 miles, as against a life of from 31,000 to 45,000 for the ordinary wheel made of poorer material.

In concluding, Mr. Johnson read a letter from A. M. Thompson of the Thompson Malleable Iron and Adjustable Clamp Company of Chicago in which he said he had to make some rolls which called for a chilled iron. He made the usual mixture of steel and ordinary iron, and test bars 2 in. by 4 in. in size showed 5/8 in. chill. Reports from the machine shop and rolling mill indicated that the surface was soft. Sulphur was added to the liquid iron and the rolls still continued soft. Some of them were taken out of the chill as soon as practicable after casting and cooled in water with no perceptible difference in hardening. A charcoal chilling iron was then purchased which proved entirely satisfactory. Previous to that he had believed in common with many foundrymen that where the fracture was white the carbon was combined, no matter what iron was used, and the limit of hardness had been reached.

H. M. Lane reported an incident where a foundryman was pouring stove plate. He used a ladle which had been dampened, after drying it slightly on the surface so that only just enough steam would form to cause the iron to boil. He poured one plate from that ladle and another from a perfectly dry ladle. When the plates were broken the first one was found to be chilled on the inside and the other was not. The steam boiling through the iron had caused some change either physical or chemical which produced an internal chill, with $\frac{1}{32}$ to $\frac{1}{16}$ in. of good gray iron on the outside, the inside being hard and white so it could not be drilled. The same thing often occurs when the bed of the cupola has not been dried out thoroughly. It causes the iron to boil at the start and the first 100 or 200 lb. will show internal white marks.

With regard to the addition of sulphur, which has been mentioned, a patent process has been introduced into this country at least five times involving the use of sulphur in steel making. It comes from Germany and consists in adding iron pyrites to a malleable charge to introduce sulphur into the iron. Two-inch and two and one-half-inch sections are chilled all the way through and when they are treated in the annealing furnace they produce a fair grade of malleable.

The Author. Mr. Beckett states that "The application of a jet of air to aid in a chilling process is a difficult matter, which will prove expensive in the long run and is not likely to come into use except in special cases." Time only can tell whether his modification of "except in special cases" will hold. The author has patented processes whereby varying conditions can be met with by the use of suction as well as with air pressure. One of these is described in Par. 59 and illustrated in Figs. 9 and 10, showing that with air treatment simple methods can be used to cool and deepen, or harden, a chill. The illustrations of the paper and specimens exhibited at the meeting forcibly demonstrate the effects of air treatment.

In commenting on Par. 65, which says "Graphitization having once taken place in the crust or hot body of a casting, no sudden cooling can restore the carbon to its original form, and only by remelting can it be so transformed as to have a chill or white iron structure," Mr. Beckett gives valuable information but little known. However, it is to be understood that the author had in mind the possibility of changing the state of the carbon at the time of making a casting. This also applies to one of the points raised by Professor Stoughton.

Mr. Munnoch's discussion states that the author's work in demonstrating that the chill structure is produced after the metal has solidified corroborates the work of E. A. Custer. The paper states that the chilling of iron must be accomplished prior to the formation of graphite, and that it has always been thought that in chilling iron the action ceases the moment the metal has solidified. This does not imply that an iron is not chilled until after the metal has solidified. The point desired to be emphasized is that chilling can be continued up to a period of 20 or 30 seconds after the moment of solidification, and Mr. Munnoch has evidently misunderstood the meaning. The writer believes that Mr. Custer's hypothesis, while having some relation to the above question, is not strictly within the lines of research covered by the paper in question.

TESTS OF CHILLABLE IRONS

By Thos. D. West, Published in The Journal for June

ABSTRACT OF PAPER

The tests given in this paper relate to the relative strength of gray iron and of partly or wholly chilled iron, showing the best combination in chilled castings. Many tests are presented of chillable iron alloyed with vanadium and titanium.

Previous to these tests experiments were made for the purpose of establishing a size of round bars suitable for making tests of chillable irons where it is necessary to have the bars either of a uniform gray structure throughout or capable of being chilled throughout, the metal in each case being poured from the same ladle.

The effect is shown on the results of tests of different methods of locating the bar in testing with regard to the quality or grain of the metal. Attention is called to the advisability of drop tests for cast iron and to the complexity and sensitiveness of chillable iron mixtures, requiring delicacy in mixing, melting, casting and testing.

DISCUSSION

A. E. Outerbridge, Jr.[1] In making comparative tests with powdered alloys in ladles of molten iron the writer always uses a cast-iron stirring rod, as he has found that a very appreciable increase in strength is imparted to cast iron by using a wrought-iron rod. He also has two sets of test molds, including long, thin fluidity strips 10 in. long by ¼ in. thick tapering to a feather edge, and uses two cleaned hand ladles, into which he pours the metal from a bull ladle. Both the treated and untreated samples are stirred with cast-iron rods and both poured at the same moment, so that all conditions are alike. Usually shrinkage test pieces are poured for the purpose of developing any tendency to produce "blow" holes at the junction of light and heavy sections. These methods date back to the time when he began and

[1] Metallurgist, Wm. Sellers & Co., Inc., Phila., Pa.

carried on long continued experiments on the effect of adding small quantities of powdered ferro-manganese to car wheel iron in the ladles, first published in the Journal of The Franklin Institute March 1888.

C. B. Murray.[1] Ever since 1908, when Dr. Moldenke read his paper on the tests of vanadium in cast iron, there has been considerable discussion as to how vanadium and titanium do really affect such iron.

When vanadium first made its appearance, and began to be used in steel, it was thought, for a time, that its action was of the nature of a scavenger or a cleaner of the metal, and that the actual presence of vanadium in the finished steel was not necessary. This idea has, however, been cast one side, and now it is pretty generally believed that vanadium acts in two ways: first as a deoxidizer, the resultant vanadium oxide going into the slag; second, that a part of the vanadium should be left in the steel. Just how this acts is somewhat uncertain, but it seems to intensify the action of carbon and other metalloids in the steel. This same theory has been applied to titanium and seems to be still held.

Mr. West has been very painstaking, and seems to have attained his object of securing two specimens of as nearly as possible the same chemical and physical characteristics. The results of the tests, however, especially with regard to the modulus, do not give much information.

The determinations of small amounts of vanadium and titanium are somewhat difficult operations and require a great deal of care and attention. The chemical determinations of these materials were very carefully made in the laboratory of Crowell & Murray in Cleveland and the writer feels assured that the results are correct.

The writer has attempted to get some data from Tables 5-9, but apparently the most marked effects of the addition of these elements is in the chilled round samples. Just why this is so he is unable to say, but it is hardly a coincidence, since in all cases where the chilled round samples can be compared the iron containing either vanadium or titanium, or both, shows a marked increase in their modulus. Possibly the effect of all the carbon being in the combined state and the fact that Mr. West has ap-

[1] Crowell & Murray, Cleveland, O.

parently secured a more homogenous thoroughly chilled sample in the round piece than in the square pieces may have some bearing on this question.

His conclusions in Par. 37 would seem to indicate that he himself is not thoroughly satisfied with the results of the test, and that perhaps some conditions regarding the temperature of pouring, or the thoroughness of mixing, may have escaped his notice, and that these unsatisfactory results may have come from such conditions.

Henry Souther. The irregularity of the figures given by the author for the modulus of the iron suggests the possibility of internal strains in the cast-iron specimens. The question arises as to whether or not these strains were relieved by partial annealing. If not, it would seem that these great irregularities may be due to uncertain internal stress.

In reference to the effect of vanadium and titanium, it appears that these alloying elements were added in the ladle and that the metal cooled somewhat because of these additions. An indication of increase of strength was obtained. It is fair to assume that the hotter the metal the slower it will cool in the molds. It is a fact that the slower the cooling, the greater the separation of graphitic carbon and the weaker the specimen. After the addition of vanadium or titanium the metal is cooler, therefore chills more quickly with less separation of graphitic carbon and has greater strength. So far as the writer has noted, Mr. West has not taken this into consideration. It is unfortunate that the iron with and without alloying elements was not poured at the same temperature.

One point the writer would like to see cleared up is the question of modulus. Various figures for the modulus appear in many of the tables. They vary widely one from the other and also from what is known of the modulus of the iron. It would be an addition to the paper could Mr. West supply the means of obtaining these figures; that is, it would be well to show the formula used and the methods taken to measure the modulus.

Bradley Stoughton. The writer is greatly interested in the effect of titanium on the strength, contraction and chilling of iron, because Mr. West's results confirm some hitherto unpublished tests of his own. Mr. West finds that titanium reduces the contraction

and the tendency to chill, which is corroborated by the writer's observations. In an attempt to prevent chilling altogether, he added first 1.14 per cent of titanium, and then 2.29 per cent; since the latter percentage did not prevent chilling as effectively as the former, he concludes in Par. 31, "that iron could not be prevented from chilling beyond a certain limit by its use." The writer's investigations showed that 2 per cent of the usual titanium alloy was sufficient to convert even a dead white iron, in bars 1½ in. in diameter, into a mottled iron, cooled in sand, and that 3 per cent of the alloy was more effective than 2 per cent. In the quality of contraction, the writer's observations corroborate those of Mr. West; namely, that titanium reduces this property. As to the most important characteristic from the commercial standpoint, strength, Mr. West finds that titanium increases the strength of white cast iron by 27 and 32 per cent respectively. The writer's results show an increase in strength all the way from small amounts up to 43 per cent, depending upon the grade of iron, the amount of titanium added and the temperature of pouring. In this connection it may be interesting to note that the writer's investigations cover also the strength of gray cast irons of a great variety of grades, and that the increase produced by adding titanium varies up to 16 per cent.

Paul Kreuzpointner.[2] In determining the quality of a material of construction for a given purpose three factors have to be taken into consideration: (*a*) The nature of the material, (*b*) the nature of the forces tending to destroy the structure, and (*c*) the proper relation of the methods employed in testing to the properties of the material. Concerning the nature of the material, it is obvious that the mechanical means used in testing must conform to that nature. What is suitable for testing cement is not suitable for testing other materials.

It is not quite so simple to determine the best manner for testing a material in accordance with that in which it is subject to destruction when in service. The forces tending to destroy a structural material may be slow-acting or quick-acting; they may be transverse, bending, crushing or tensile forces or a combination of any complicated by variation of temperatures. Thus, chillable irons are chiefly used where they are subjected to

[2] Secy. Am. Fdymen's Assoc., Altoona, Pa.

crushing and bending stresses; hence the best manner of testing them is by the application of a crushing, bending and drop or pendulum test.

However much the qualities of structural materials of the same class may vary in accordance with the requirements for a given purpose, all metals have certain properties which are the same; that is to say all metals are elastic, ductile, strong in power of resistance. Each and all of these properties vary in degree but not in kind. This being so, it may be concluded that according to the third factor in testing materials, the methods must have uniformity in all such cases where the degree of the property of a metal determines its suitability for a given purpose. Thus, if ductility is the measure of quality of a metal for a given purpose, it is by no means a matter of indifference what size of test section is used nor whether the same section is used every time or not.

Erroneous results will surely be the result of testing whenever there is a departure from a standard uniform test section or a recognized standard width of support simply because it is convenient for the time being to vary the method.

As already said all metals are plastic though they vary in degree of plasticity, and to this is due the fact that all metals flow under pressure. But the degree of flow in a test piece under test is free or is influenced by the length of the test section or the width of supports or the distance of the grips. Hence in judging of the value of the results of a series of tests, as in Mr. West's paper, for determining the quality of a metal for a given purpose, it should be ascertained at the same time whether the methods employed, speed of machine, test section, width of supports, etc., represent a recognized uniform standard.

The Author. Comments have been made on the value of test bars. It is not so much that we have no information that can be compiled to guide us as it is the indifference and often inability of many to digest what we have. Many test bars are of little value for making comparisons or obtaining the relative physical qualities of cast iron unless properly made. Owing to the lack of proper methods for this work the writer considers the majority of tests to be questionable.

As an example, compare the methods illustrated in Figs. 1 and 2 where one bar provides for two or three tests, with casting

one bar one day for one test and another bar for a second test another day. Under the latter condition there may be a variation in coke, iron and scrap, method of charging, blast pressure, temper of sands, methods and manner of holding, temperature of metals and speed of pouring, etc. The writer has given a great deal of study to the origination of methods best adapted for securing comparative results in the use of test bars. It is shown in the past methods advanced for making test bars as well as in those for obtaining the results given in the paper.

Mr. Souther comments on the evils of variation in pouring temperatures of metals for making comparative test bars. The writer labored to govern this factor, as far as conditions would permit. However, he believes that what irregularities did exist in this factor was not so great as to affect the results. This can be seen, for example, in the difference of strength of like bars having ferro-manganese in them, and those without it as recorded by the tests No. 55 to 59 when compared with those Nos. 65 to 68.

In response to Mr. Souther's request that the formula be given and the method described for measuring the modulus, the following has been prepared by A. G. Smith, who coöperated with the author, and is referred to under "Credit for Professional Coöperation" in the paper:

The question of modulus of rupture which Mr. Souther raises is quite important. We agree that it does not indicate the actual strength of the iron, and is, in fact, only a conventional figure for the reduction to a common basis of tests on similar but slightly varying bars. For example, bars nominally two inches square may actually vary from 1.95 to 2.05 in. in one of both dimensions. If no allowance is made for this variation, the results may be very misleading. The modulus was calculated according to the following very familiar formulæ:

$$M = \frac{3}{2}\frac{Pl}{bd^2} \qquad \text{for rectangular bars.}$$

and

$$M = \frac{3}{2}\frac{Pl}{0.59D^3} \text{ for round bars.}$$

Where

M = modulus

P = breaking load

l = length of bar in inches (between supports)

b = breadth of bar in inches
d = depth of bar in inches
D = Diameter of bar in inches

The actual measurements of the bars and the actual breaking loads are given with each table.

It is to be understood that none of the figures refer to modulus of elasticity; only to the so-called modulus of rupture.

COMMERCIAL DICTATING MACHINES

At the meeting of the Society in New York, May 14, 1912, the subject of Commercial Dictating Machines [1] was discussed. A. J. McFaul, of the Allen Advertising Company, New York, and Otto Brushaber, of the Dictaphone Company, New York, treated the mechanical method of recording and reproducing sound; and C. K. Fankhauser, of the American Telegraphone Company, Springfield, Mass., the magnetic method of recording sound.

Mr. McFaul said that the dictating machine did not become an article of commerce until the latter part of 1888 and the beginning of 1889. It was the joint invention of Chichester A. Bell, a cousin of Alexander Graham Bell, and Charles Sumner Tainter, who had been working jointly on the problem of recording and reproducing speech for a number of years prior to its public announcement. The graphophone differed from the phonograph, with which Edison had startled the world some ten years previously, in that it recorded sounds by a process of engraving a continuous spiral groove on a wax cylinder or disk, as distinguished from indenting the sound wave on a sheet of tin foil stretched around the mandrel.

The invention of the Bell and Tainter graphophone provided a means for permanently recording and indefinitely reproducing sounds. The original machine, as offered to the public, had somewhat the appearance of a sewing machine, its power being supplied by a treadle and flywheel. The cylinder on which the sound was recorded consisted of a paper base or core with a thin coating of wax composition on which the record was engraved by means of a steel stylus or engraver, mounted on a diaphragm, feeding across the machine while the cylinder revolved in such a manner that the recording tool engraved a spiral groove on the surface of the cylinder.

The official reporters of debates of the United States Senate

[1] Published in abstract only. Complete report may be consulted in the rooms of the Society.

and the House of Representatives and practically all of the leading court reporters in Washington were among the first to adopt the machine into practical work. Its introduction into the work of reporting debates of the Senate and House was one of its earliest triumphs. By the use of the graphophone the official reporters were enabled to cut their amanuenses staff in half, the amanuenses were able to do twice as much work in the same time, and the result was a saving in expense to the reporter and the ability to finish the day's work within one hour or less after the time of adjournment of the respective chambers.

Improvements were made from time to time, simplifying and perfecting the mechanism and operating, but the underlying principle has always remained the same. The substitution of electric and clock-work motors, provision of much more sensitive and accurate recording and reproducing mechanism, development in the material and quality of the cylinder and simplification of the whole mechanism of the machine gradually followed.

The use of the talking machine as a means of entertainment so caught the public fancy that the manufacturers of both the graphophone and the phonograph were practically forced to devote most of their manufacturing facilities and the time and attention of their organizations to meeting the demand for what has now developed into musical instruments of acknowledged supremacy.

Towards the latter part of 1907 a new model dictation machine was designed in the laboratories of the American Graphophone Company, and about the same time the Edison Company brought out a new model of their machine designed expressly for business use; and the almost simultaneous appearance of these machines, coupled with the ability of the manufacturers to give that branch of the business the attention and exploitation it deserves, and the widespread advertising they are now devoting to the subject, have given the dictation machine a fresh impetus.

The use of dictation machines as substitutes for stenographers in office work has been steadily increasing and today there are many thousands of them in daily use throughout the country. They offer to the man whose time is valuable the advantage of being able to dictate whenever he pleases, as rapidly as he pleases, and with the certainty that what he has dictated can be reduced to writing by any intelligent person.

There is no room for doubt that where intelligent and fair

effort has been applied to dictation machines, saving of time, labor and money have been effected. It has been clearly proved that there is a distinct saving in time and an appreciable increase in efficiency on the part of the dictator of from 25 to 50 per cent; while the productive capacity of the typist under normal conditions is increased by 50 per cent and has been known to run as high as 150 per cent.

In one department of a large railroad system 17 stenographers were employed, turning out an average of 75 letters per day. The introduction of the dictating machine enabled them to reduce their stenographic force to eight typists, each one of whom turned out an average of 144 letters per day, an increase of nearly 100 per cent in the productive capacity of the stenographic force accomplished at a reduction in payroll of over 50 per cent.

Another user of dictating machines has certified that the cost of reproducing dictated and typewritten letters has been reduced from 5½ cents per letter by the stenographic method to 2¼ cents by the dictating machine method. Still another user estimated that each machine saves its own cost in operating expenses every 60 days.

Instances of this sort could be cited indefinitely; but the most striking endorsement ever given is that recently published by the United States Government. The President's Commission on Economy and Efficiency in a report recently issued, gives statistics of a test of dictation machines as compared with the use of the shorthand amanuenses from which it deduces that "if the dictation machine were used in all cases where possible in the executive departments in Washington the saving would be more than $500,000 a year."

Mr. Fankhauser said that the principle upon which the Telegraphone is based is that a mass of tempered steel may be impressed with and will retain magnetic fluxes varying in density and in sign in adjacent portions of its mass.

The action of the wire telegraphone in recording is as follows: A tempered steel wire is caused to pass at a uniform rate of speed successively before and in contact with the pole of a soft iron electro-magnet designated as the "erasing" magnet, and before and in contact with the pole of another similar electromagnet designated the "recording" magnet.

Through the winding of the erasing magnet is passed an elec-

tric current of sufficient strength practically to saturate the steel wire magnetically and a portion of this current is caused to pass through the winding of the recording magnet in a direction to give the magnet a tendency to reverse the direction of the magnetic flux in the steel wire in order to bring the wire into a magnetically neutral condition.

The winding of the recording magnet is also included in the circuit of the secondary winding of an induction coil, the primary winding of which is in circuit with a battery and telephone transmitter.

Sound waves as from spoken words, etc., impinging upon the transmitter diaphragm and through its vibration setting up correspondent current waves in the circuit of the secondary winding of the induction coil and recording magnet will cause varying fluxes to traverse the magnetic circuit of the recording magnet, which will cause similar fluxes to be impressed upon successive portions of the steel wire as it passes before the pole of the recording magnet.

In reproducing the record, the erasing current is discontinued and a telephone receiver is introduced into the circuit of the recording magnet winding.

Upon causing the steel wire carrying the magnetic record again to pass before the pole of the recording magnet at the same speed and in the same direction as when making the record the varying fluxes in the wire will set up corresponding fluxes in the magnetic circuit of the recording magnet, thus inducing current waves of similar value in the winding and circuit of the recording magnet and the telephone receiver.

The receiver diaphragm vibrating in unison with these currents will set up sound waves similar to those acting upon the telephone transmitter in making the record.

The machine itself may be located at any distance from the dictator. Whether it be 10 ft. or 10 miles it makes no difference in the matter of dictating with comfort and ease. The dictator is supplied with an extension set containing an electric indicator which at all times gives the position of the wire on the reels and enables him to determine just how much of his recording body he has used and how much is yet available without changing the reels. There are three push buttons which give him absolute control of the machine; one for running forward, one for stopping and one for backing it up. In addition to this he is supplied

with a transmitter and a receiver and with a button or spring which may be located in any convenient place either on the extension set or on the receiver or transmitter, which button operates the erasing circuit of the machine. When this button is pressed so as to make contact, and the machine at the same time runs forward, one set of magnets erases any previous records that may be on the wire. Thus he is thoroughly equipped for dictating, for listening to his own dictation, for erasing and making corrections, and in fact for doing everything except changing the reels if they are filled and new ones required. This must be done by some one near the machine.

The arrangement is such that erasing a previous record is not a separate operation. This is automatically done while new dictation is being put on the same wire, for the wire must pass the erasing magnet before it reaches the recording magnet. It is only necessary to press a button and put the erasing magnet in circuit in order to secure a clean wire for the new dictation.

If an error is made or a correction or change is desired the dictator has only to reverse the machine, back up to the desired point, listen to his dictation through the receiver, and redictate that part which is unsatisfactory, at the same time erasing the former or unsatisfactory dictation.

Thus he is at once equipped for 30 minutes' continuous and uninterrupted dictation, at all times having his "stenographer" under perfect control. If he dictates longer than 30 minutes he is interrupted for only the fraction of a minute while the filled reels are being removed and new ones put in the place of them.

It is also a machine for reporting telephonic conversation, and there are appliances for connecting the machine to telephones in cities at great distances and reporting what is said directly into the machine. It is possible even to record speech when a person is standing 10 ft. away from the transmitter.

Mr. Brushaber said that the first idea of the use of the dictating machine was not so much to increase the efficiency of help, but to decrease it by the employment of cheaper labor. The real economy of the dictation machine comes from the fact that the payroll may be cut down as desired or the efficiency of both dictator and transcriber, as compared with the process of taking and transcribing stenographic notes, be increased.

With the dictating machine method of handling correspond-

ence the man reads the letter, gives it the necessary attention in order that he may reply to it properly, and then dictates the reply to the dictation machine. If he requires something from the files in order to enable him to reply to the letter in a proper manner he dictates a memorandum on the dictation machine, and then lays the letter aside in order that the data may be looked up, and brought to him. He then takes up the next letter and dictates the reply, and so on, until he has finished his mail. The dictation of the reply is done while the subject matter of the correspondence is fresh in mind. The work of the correspondence is despatched with ease and accuracy, and the machine may be used instantly without any delays incident to the movements of a stenographer.

In the case of an express company $200 a month was saved after the installation of the dictating machine. The same amount of work is done with nine machines which formerly required thirteen stenographers. There has been an increase of 45 per cent of the letter writing capacity, making it possible to keep their current claims up to date. Moreover it was found that work was transcribed so accurately that it did not require a re-reading on the part of the dictator which was formerly necessary under the stenographic method.

A general discussion followed the presentation of the papers.

S. H. Bunnell said he found it a great annoyance to have to stop dictating, often in the middle of an important sentence, to adjust a new cylinder. Another objection he had to the use of the machine was that it was practically impossible to record figures, there being no way for the transcriber to distinguish between fractions and decimals. He also had difficulty in making corrections. In simple dictation, such as letters, etc., changes were easily made, but in dictating specifications, and similar matter, where there are many clauses here and there to be changed it is a source of considerable annoyance.

Jos. F. Diepenbrock[1] said the success of the machine depended on the good will and patience of the operators; also upon the manner in which the dictator talked into it. He had reduced his office staff from five stenographers to two dictating machine transcribers, and had found it possible to cope with a large amount of mail in a very short time.

[1] Harrison, N. J.

T. C. MARTIN, JR.[1] found the machine of special value in connection with form letters where he had been able to save time and expense in inserting special paragraphs. There would be less opposition to overcome if in installing the machine the higher officials were given it first, then the lesser ones and subordinates. He considered the dictating machine as important an asset to office equipment as the telephone.

W. W. MACON spoke of the difficulty of recording sibilants. F and S are particularly difficult letters to catch on the dictating machine just as on the telephone.

H. R. COBLEIGH said he has used the dictating machine for five years and was thoroughly satisfied with it.

H. J. K. PORTER inquired whether or not the machine could be used to handle the proceedings of a meeting conducted in foreign languages, and C. K. Fankhauser answered him in the affirmative.

[1] Secy., Natl. Elec. Lgt. Assoc., New York.

FOREIGN REVIEW

BRIEF ABSTRACTS OF CURRENT ARTICLES IN FOREIGN PERIODICALS

CONTENTS

FOREIGN REVIEW

The aim of the Foreign Review is to present, within the available space, the main data contained in the article indexed. Where possible, reference is made to English or American publications containing fuller information on the subject treated. Measures are given both in original units and their English equivalents. In many instances, engravings and tables are reproduced. Opinions expressed are those of the reviewer, not of the Society. Articles are classified as *c* comparative; *d* descriptive; *e* experimental; *g* general; *h* historical; *m* mathematical; *p* practical; *t* theoretical. Articles of exceptional merit are rated *A* by the reviewer.

Air Machinery

Resonance Phenomena in the Suction Piping of Compressors and Gas Engines, see **Mechanics.**

Staurohr, Apparatus for Measuring Air Volumes and Air Pressures, see **Heating.**

Firing

Mechanical Firing with Special Regard to Firing with Lignite Briquettes (*Maschinenfeuerungen unter besonderer Berücksichtigung der Braunkohlenbrikettfeuerung*, Weilandt. *Zeits, für Dampfkessel und Maschinenbetrieb*, March 29 and June 14, 1912. 8 pp., 27 figs. *d*). Description of various types of furnaces, with particular attention to those for firing with lignite briquettes. Some of the types described in the article have been already mentioned in this *Review.*

Heating

Investigations at the Laboratory for Testing Heating and Ventilating Installations of the Royal Technical High School at Berlin, with an Appendix on Utilization of Exhaust Steam (*Forschungsarbeiten der Prüfungsanstalt für Heizungs- u. Lüftungseinrichtungen der Kgl. Technischen Hochschule Berlin nebst einem Anhang über "Abwärmeverwertung,"* K. Brabée. *Gesundheits-Ingenieur*, May 25 and June 8, 1912. 22 pp., 65 figs. *ed A*). Condensed account of the work done lately by the above laboratory, with brief description of the apparatus used and some methods of testing. Of the apparatus the most interesting is the one

shown in Fig. 1, called "Staurohr," and used for measuring air-volumes and air pressures. In conjunction with two other apparatus, volumeter and manometer, the Staurohr may also register the air volume and pressure. It consists of a plain, smoothly turned, cylindrical tube enclosed in another tube, both ending in a conical extension. The inner tube takes care of the total pressure, static and dynamic; the outer, through its fine openings, only of the static, which permits the elimination of it in measuring the velocity of the air. The same apparatus has also been adapted for water measurements.

The laboratory made more than 300 tests of protective coverings, and found that they may reduce the efficiency of the heating apparatus as much as 40 per cent.

The article describes very interesting tests on the influence of increased velocity of air and eddies in air on the giving up of heat by heating apparatus, as well as tests of automatic temperature regulators of hot water and low-pressure steam heating installations. The laboratory made extensive

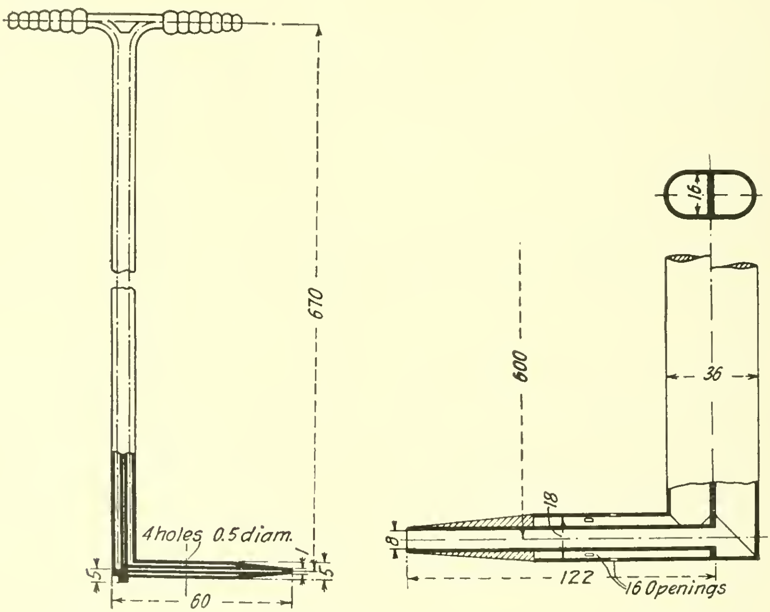

Fig. 1 "Staurohr" for Measuring Air Volumes and Pressures

tests with steam traps, and found that with large amounts of water the traps work practically with no losses, but show considerable losses with small amounts of water; that the maximum efficiency of the traps depends on the temperature of water, and that the pressures in open outlets cannot always be neglected.

Internal-Combustion Engines

Motor Fire Engines (Three articles on the efficiency and construction of motor fire engines under the following titles: *Die Fahrgestelle und Pumpen der Feuerwehr-Motorspritzen*, Schwedtfeger; *Die Entwicklung der Motorspritzen, die Ergebnisse der stattgefundenen und der Wert der geplanten Prüfungsfahrten mit Motorspritzen*, A. Bauschlieher; *Zur Frage der Feuerwehr-Fahrzeuge*, M. Reichel). *Der Motorwagen*, June 10, 1912.

Spray Carburetor Indicator (*Indikator für Einspritz-Vergaser*, G. Bergmann. *Der Motorwagen*, June 20, 1912. 5 pp. 8 figs. *cdA*). Beginning of a series of articles on the use of a special device for indicating pressure variations in a high-speed piston engine, the first purpose of the tests having been to investigate the processes in a carburetor of a high-speed benzene motor. A fuller account will be given later.

Resonance Phenomena in the Suction Piping of Compressors and Gas Engines, see **Mechanics.**

Machine Shop

Power Required by Bending Machines (*Der Kraftbedarf von Biegemaschinen*, S. Zander. *Werkstattstechnik*, June 15, 1912. 1 p., 3 figs. *t*). The author shows that the power required for bending machines cannot be determined from the usual formula $M = W. K$, where K is the stress at the yield point, because this formula has been developed on the assumption of the proportionality of deformation to the stress in the fiber, and therefore may be applied only to stresses under the elastic limit, while in the bending machines the stresses which are required to produce a permanent deformation must be carried beyond the elastic limit, to the yield point. The actual power required is considerably higher than would appear from this formula, and may be obtained by substituting for K not the stress at the yield point, but a higher value, such as the breaking strength of the material.

Calculation and Design of Belt, Hemp Rope and Wire Rope Pulleys (*Die Berechnung und Construktion von Riemen-, Hanfseil- und Drahtseil-Scheiben*, Paul Haupt. *Zeits. für Elektrotechnik und Maschinenbau*, June 5, 1912). Beginning of a series of articles on the calculation and design of various pulleys, of a rather elementary character, mainly for young designers.

A System of Taps and Dies (*Système de Tarauds et Filières. La Métallurgie*, June 26, 1912. 1/3 p., 4 figs. *d*). Description of a system of taps and dies patented by the Société des ateliers Minne et Stempert and based on the principle of cutting the screw thread by a relieved tool, working only with its back cutting edge, having no side friction, and providing for a free passage of the lubricant down to the cutting edge of the tool, and even under the chip. Fig. 2 A shows how a thread is cut by an ordinary tap filling the space entirely, producing a powerful friction on the thread, and pushing the lubricant in front of the chip. B shows the same kind of work being done by a tap constructed on the above principle, with the faces of the teeth relieved of all unnecessary friction, and plenty of room for the lubricant. Since however in this system the teeth have a pro-

file different from that of the thread to be cut, they have to be disposed in such a manner that their back edges should successively cover the entire face of the thread. C shows how this is done. The thread to be cut is a truncated triangle, and B is a part of the tap; the full lines indicate the profile of the trap, and the broken lines that of the thread. The tap is at first cut with a profile adopted, but sharper than that of the thread, and in a cone of diameter decreasing from a to b in such a manner that the vertices a and b are common to both profiles. Then the exterior of the thread is

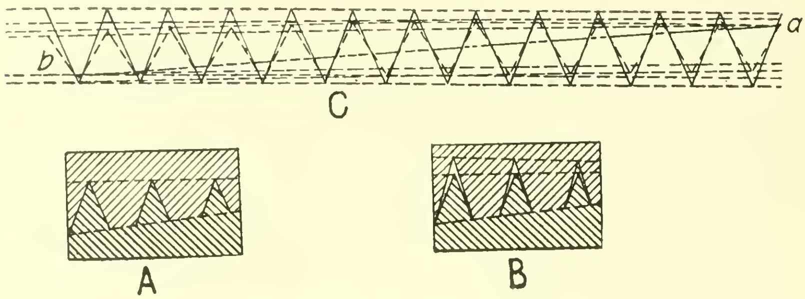

Fig. 2 Minne and Stempert Taps

turned in diminishing cones from b to a, the conical surface obtained being the intersection of the two threads considered. (The above is practically a word for word translation of the original article.)

Mechanics

Losses in the Transmission (*Pertes dans la transmission*, G. Lienhard. *La Technique automobile et aérienne*, May 15, 1912. 3½ pp., 4 figs. *t*). Theoretical, mainly mathematical investigation of transmission losses, with special reference to *losses in universal joints*. The author derives the following equations:

For useful work of the joint: $T_u = \frac{\pi}{2} M_o$

For total work: $T = T_u + T_f$

For efficiency of the joint:

$$\rho = \frac{T_u}{T_u + T_f} = 1 - \frac{T_f}{T_u + T_f}$$

where M_o is the moment of resistance at the bearing (say at B, Fig. 3) with respect to the axis of the shaft normal to the plane of the great circle AB, this moment being equal to the force F acting on the journal B. The author shows further that

$$\frac{T_f}{T_u} = \frac{2r \sin \psi}{\pi R} \left[\text{Log } tg \left(\frac{\pi}{4} + \frac{A}{2} \right) + tg\ A \right]$$

and that the efficiency of the joint is zero for angle $A = \frac{\pi}{2}$. A universal joint cannot of course be used for the transmission of efforts at right angles; the efficiency increases as one shaft tends to become the prolongation of the other, and when

they do become so, the efficiency is unity, and the joint is useless. For small values of A, as is generally the case, the value of T_f is small in comparison with T_u, and the equation for efficiency may be written thus:

$$\rho = 1 - \frac{T_f}{T_u}$$

or

$$\rho = 1 - \frac{2r \sin \psi}{\pi R}\left[\log tg\left(\frac{\pi}{4}+\frac{A}{2}\right)+tg\, A\right]$$

Developing it into a series and taking only the first terms:

$$\rho = 1 - \frac{4\, Ar \sin \psi}{R}$$

This form shows clearly the influence of the different elements of the joint. To increase the efficiency: (*a*) it is well to decrease A as far as possible. The

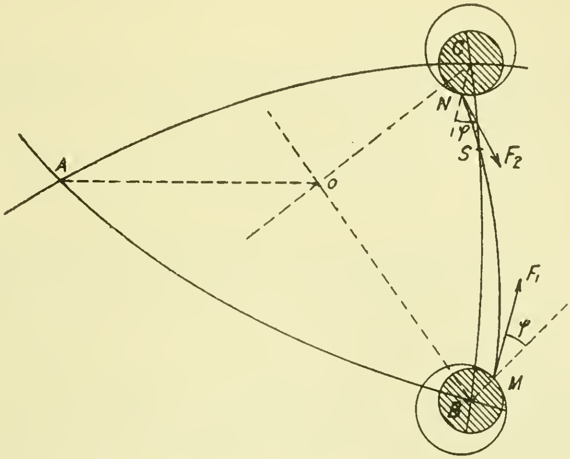

Fig. 3 Diagram of Universal Joint

author states that although that is practically self-evident, there are still many joints made with the driving and driven shafts, making an appreciable angle between them; (*b*) the radius of the journals must be made as small as possible, and therefore the strongest materials must be used for them; (*c*) the angle ψ must be made as small as possible, or the best lubrication must be used; (*d*) R must be made as large as possible: the influence of this factor is as a rule very little realised.

The author applies his formulae to the examination of a particular joint.

The second part of the article is devoted to the investigation of friction in the steering swivel. The author considers the leading axle, and supposes the load on the axle to be constant; this is really not correct, but the average load differs but very little from the static load on the axle. The author deduces finally the

following equation for the tractive effort ε which would produce uniform motion:

$$\varepsilon = 2\frac{k}{R}(P-p) + \frac{2\,Pr\sin\varphi}{R}$$

where $2P$ is the total load on the axle, $2(P-p)$ the load on the ground, p the weight of a wheel, r radius of the journal, R radius of the wheel, k parameter of resistance to rolling of the wheel which varies with the state of the road and the inflation of the tire, φ angle of friction at surfaces of contact.[1] This equation shows that the losses in the wheels are the sum of the losses incurred in the journals and in rolling over the ground. It shows also that: (a) the weight of the wheel comes in only in one term, and has little influence on the uniformity of motion; (b) ε decreases as R increases, and there is therefore a considerable advantage in having the radius of the wheel as large as possible; (c) k must be as small as possible; it depends directly on the inflation of the tires, and indirectly on the suspension, in that a good suspension decreases k by absorbing the shocks and decreasing the wear of the tires; (d) the angle φ must be made as small as possible, by good lubrication and the use of ball bearings; (e) the diameter of the steering swivel must be as small as possible.

Universal Joints in Automobile and Boat Construction (*Kardangelenke im Automobil- und Bootsbau*, H. Regensteiner. *Zeits des Mitteleuropäischen Motorwagen-Vereins*, Mid-June 1912, 10 pp., 13 figs. tA). A very interesting investigation, mainly mathematical, of the universal joint, along lines similar to those in the article of G. Lienhardt (p. 1242). Owing to lack of space only the part of the article referring to friction losses in the universal joint is here abstracted.

The friction in a universal joint with a Cardan bolt consists of the friction between the bolt and trunnion block, between block and lateral guide and block and outer guide. The following symbols will be used: G weight of trunnion block in kg; $m = \frac{G}{g}$ its mass; n speed of driving shaft in revolutions; Md moment of torsion of the driving shaft in kgm; a radius of the housing of universal joint in m; δ angle between the two axes in arc units; $a\rho$ distance of the center of pressure of a trunnion block in m; $b\rho$ radius of the Cardan bolt in m; μ coefficient of sliding friction between the housing and block; μ_1 coefficient of sliding friction between nut and block.

The friction between block and nut is due to the action of the force $P = \frac{Md\,\mu_1}{2a\rho}$. The distance through which the force acts in a second is $s = \frac{4\,b\rho\,\delta\,n}{60}$. The friction loss for two blocks in h.p. is therefore

$$N_{\mu_1} = \frac{4\,Md\,b\rho\,\delta\,n\,\mu_1}{60\cdot75\,a\rho} = \frac{4\,Md\,b\delta n\mu_1}{60\cdot75\,a} = \frac{1}{15\cdot75}Md\,\frac{b}{a}\delta n\mu_1.$$

The friction between guide and block is due to the action of the force $P_1 = \frac{Md\,\mu}{2\,a\rho}$, and the distance through which this force acts is $s_1 = \frac{4\,a\rho\,\delta\,n}{60}$, the loss in h.p. being

[1] In the original reference is made to a figure which is not given; Figs. 5 and 6 are omitted in the original.

$$P_{fs} = \frac{4\, M_d\, a\varrho\, i\, n\, \mu}{60 \cdot 75\, a\varrho} = \frac{1}{15.75} M_d\, i\, n\, \mu$$

The friction between the cover of the housing of universal joint and the blocks acted on by centrifugal force is due to the action of a force P_c proportional to the centrifugal force, and equal to $\frac{m\, 4\, \pi^2 n^2 a\varrho}{3600}$ if the center of gravity of the block is $a\varrho$ distant from its center, while the distance through which this force acts in a second is $s_3 = \frac{4\, a\, i\, n}{60}$, the loss in h.p. being

$$P_{gs} = \frac{32\, m\, \pi^2 n^3\, a\varrho^2\, i\, \mu}{60^3 \cdot 75} = \frac{320\, m\, n^3\, a\varrho^2\, i\, \mu}{60^3\, 75}$$

The total loss in h.p. is therefore

$$P = P_{bs} + P_{fs} + P_{gs} = \frac{1}{15.75} M_d \frac{b}{a}\, i\, n\mu_1 + \frac{1}{15.75} M_d\, i n \mu + \frac{320}{60^3\, 75} m n^3\, a\varrho^2\, i\mu =$$

$$\frac{M_d\, i\, n}{15.75}\left(\frac{b}{a}\mu_1 + \mu\right) + \frac{320}{60^3\, 75} m n^3\, a\varrho^2\, i\, \mu.$$

In universal joints with two Cardan bolts normal to each other the friction between block and guide and block and housing is eliminated, while the friction between block and nut is twice as large as in the preceding case because the joint has four instead of two blocks. The total friction is therefore

$$P = P_{bs} = \frac{2}{15.75} M_d \frac{b}{a}\, i\, n\mu_1.$$

Usually μ is nearly equal to μ_1, and a is from four to six times as large as b, and on the average may be taken to be five times as large. On this assumption the total loss in the guide may be taken to be five times as large as between bolt and block. The universal joint with two Cardan bolts or with four blocks is in nearly every respect superior to joints of simpler construction.

Theory of Friction in Lubricated Machine Parts. *Zur Theorie der Reibung geschmierter Maschinenteile.* L. Ubbelohde. *Petroleum*, May 15 and June 5, 1912. 10 pp., 9 figs. *tA*. Continuation of the article on the theory of friction in lubricated machine parts abstracted in *The Journal* for June 1912, p. 969. Petroff (*Neue Theorie der Reibung*, Hamburg, 1888), who was the first to investigate theoretically the laws of friction in lubricated bearings, is the originator of the so-called hydrodynamic theory according to which the phenomena of friction in bearings are governed by the laws of internal friction of the lubricant. On the supposition that the lubricant adheres both to the journal and the bearing and the journal is concentric with its bearing, the velocity fall in the lubricant may be expressed as

$$\frac{dv}{dn} = \frac{U}{\delta}$$

where U is the velocity at the surface of the journal, and δ the thickness of the layer of lubricant, supposedly small and uniform. The moment of friction on the journal may then be expressed (according to Newton's law) by the formula

$$M = r\, \eta\, F \frac{U}{\delta}$$

where r is the radius of the journal, and F the inner wettened surface of the bearing. According to this formula the friction is proportional to the velocity U, contrary to Coulomb's law.

Reynolds and especially Sommerfeld have shown, however, that, contrary to Petroff's assumption, the journal is not concentric with the bearing, but is somewhat eccentric, the eccentricity being proportional to pressure and inversely proportional to velocity. Fig. 4 represents graphically the relation between the velocity U (abscissae) and the coefficient of friction μ. In this figure P is pressure, η viscosity or internal friction of the lubricant, δ difference between the radii of the bearing and journal, which was defined above as thickness of layer of lubricant, because of the supposition of its being uniform. This figure shows that for zero velocity the coefficient of friction has a definite value equal for all pressures; with increasing velocity it decreases a little at first for all pressures, and then begins to increase. The minimum value of the coefficient of friction is the same for all curves (line b), and is equal to $\mu_{min} = 0.943\mu_o$. It depends thus,

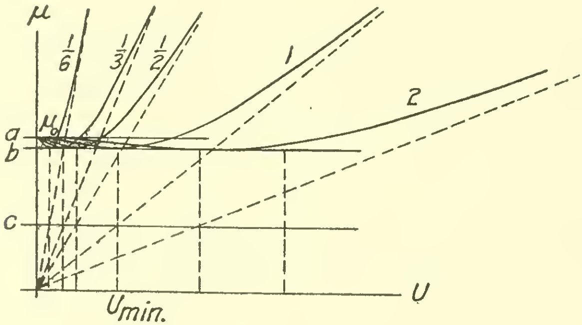

FIG. 4 SOMMERFELD FRICTION DIAGRAM

like the coefficient of friction of rest, only on the dimensions of the bearing, is about 6 per cent less than that coefficient, and is independent of the journal pressure and journal velocity, which are of material influence in shaping the rest of the curve. The greater the pressure the higher is the velocity at which the minimum coefficient of friction is reached. This velocity is denoted by U_{min} and called "velocity of transition," the corresponding pressure P_{min} being called "pressure of transition," and both expressed by the following formulae:

$$U_{min} = \frac{\delta^2 P}{15.1 \eta r^2}$$

and

$$P_{min} = 15.1 \frac{\eta r^2 U}{\delta^2}$$

which show that the value of velocity of transition grows with the growth of the journal pressure P, and with the decrease of viscosity of the lubricant. Since, however, viscosity falls noticeably when temperature rises, we may say that

velocity of transition rises with rise of temperature. At high velocities the separate curves lie asymptotically to broken lines passing through the origin, and representing the equations

$$\mu = \frac{2\pi\eta\, r\, U}{\delta\, P}$$

and

$$\mu = \frac{2\pi\delta}{15.1r} = 0.416\mu_o$$

of which the second is for $U_{\min}$. Accordingly, a line c parallel to the axis of abscissae is drawn at a distance $0.416\mu_o$ from the origin, and the asymptotes of all the curves are obtained by connecting with the origin the points of intersection of this line with the ordinates at $U_{\min}$.

These theoretical propositions have been found to agree fairly well with data obtained experimentally by Striebeck (*Zeits. des Vereines deutscher Ingenieure*, 46, 341, 1902), while the not very considerable discrepancies between the theoretical and experimental values are explained by the author by the fact that, especially at low velocities, we have to deal not with pure liquid friction, but also with dry friction produced by direct contact between journal and bearing (proof-electric contact) which materially increases the total resistance.

To prove the correctness of the contention that as far as the oil is concerned, viscosity is the only factor affecting the coefficient of friction, it was sufficient to show experimentally that all oils of equal viscosity would have the same coefficient of friction in a bearing. Extensive tests in this direction were made by the author with a Martens machine for testing oils, with simultaneous determination of the viscosity of oils tested at the temperature which the oil had during the test (complete table of data is given in the article). These tests have shown that the coefficient of friction is the same not only for all oils having the same viscosity at the same temperature, but even for oils having the same viscosity at different temperature. It was also found that the coefficient of friction increased with the increase in viscosity.

Some of the general results of these tests are of interest. The tests have been made with oils of very different grades, origin, and price, but as far as the coefficient of friction is concerned, practically all the oils were found to behave exactly alike, and particular origin, make, or degree of refinement were found to be immaterial, the only really important mechanical factor being the viscosity. This is true, of course, only when the presence of asphalt or similar matter in the oil is not harmful, as is the case when the oil is not exposed to too high temperatures, but cannot be applied literally in the case of superheated steam cylinder lubrication, lubrication of air compressors, etc., where the oil must be free of easily decomposable substances and otherwise very pure, not for mechanical reasons, however, but because in decomposing it generally forms undesirable residues.

The author does not believe in testing lubricants in the existing special testing machines because: (*a*) the coefficient of friction depends on viscosity alone, and therefore a viscosity determination is entirely sufficient, direct measurement being superfluous; (*b*) it depends quite materially on the shape of the bearing, especially on the difference between the radii of the bearing and journal, and

that the testing machine does not show. It would therefore be entirely wrong to use for practical purposes data obtained on testing machines. It may be pointed out here that Professor Thurston, in his *Treatise on Friction and Lost Work in Machinery and Millwork* (New York, 1885, p. 192), stated that the viscosity test "is regarded as quite as satisfactory as any single physical or chemical test known, and as second only to the best testing machine methods," but at that time he denied (ib. p. 98) that viscosity affects the value of the coefficient of friction.

The author considers one of the greatest difficulties in connection with the problem of efficient lubrication the overcoming of dry friction between the journal and bearing which might theoretically be eliminated only under the following conditions: (*a*) preservation of a definite constant velocity and definite constant pressure; (*b*) definite viscosity of the oil; (*c*) proper dimensions and very smooth surface of the parts in rolling contact. Practically in nearly all cases these conditions cannot be maintained for any length of time. The speed of rotation of machinery changes very frequently; the load naturally varies also; the viscosity of the oil is subject to changes with temperature, while the surface conditions and dimensions of the parts in rolling contact may both vary with temperature, and be affected by wear. Dry friction cannot therefore be eliminated entirely, and the best that can be done is to reduce it as much as possible. The rest of the article is devoted to the discussion of the applicability for this purpose of artificial graphite lubricants, mainly on the basis of data obtained by American investigators.

Note on the Design of Volute Springs (*Contribution au calcul des ressorts à boudin, d'après H. Al. Siebeck. Revue de mécanique*, June 1912. 9 pp., 5 figs., 2 tables. *t*). French translation of the article under the same title in the *Zeits. des Vereines deutscher Ingenieure*, fully abstracted in *The Journal*, April 1912, p. 627.

Resonance Phenomena in the Suction Piping of Compressors and Gas Engines (*Resonanzerscheinungen in der Saugleitung von Kompressoren und Gasmotoren*, P. Voissel. *Zeits. des Vereines deutscher Ingenieure*, May 4, 1912. 3 pp., 11 figs. *etA*). An article by E. W. Koester in *Zeits. des Vereines deutscher Ingenieure*, January 23, 1904, contained a number of indicator diagrams for a Koester compressor. The suction lines in these diagrams showed some regularly occurring oscillations which, when transformed into a time-pressure curve, gave a line similar to a sinusoid, which was the same as long as the speed of the compressor remained constant, but varied in phase with the change of speed. There was a complete oscillation for each stroke. In diagrams taken with the suction piping cut out, the suction line was straight, and coincided with the atmospheric. Similar periodic variations of pressure occur in the piping of gas engines, while their safety of operation requires that the admission of gas and air should be entirely free from irregularities of working, and depend exclusively on the system of governing.

Professors Sommerfeld and Debye were the first to recognize these pressure variations as belonging to the class of resonance phenomena. Since the velocity of the piston in each stroke varies from zero to maximum and

back to zero again, and the air in the cylinder must follow the piston, there arise in the piping longitudinal air oscillations which are reflected at the open end of the pipe. Vertical waves are produced, and the suction piping acts approximately as a "covered" tube, i. e. one closed at one end, and open at the other. In the Sommerfeld-Debye theory a differential equation of the wave motion in the pipe is derived from Euler's fundamental hydrodynamic equation and, by integration, the pressure variation corresponding to given limiting conditions is developed as a periodic time function in the form of a Fourier series. The pressure variation is thus

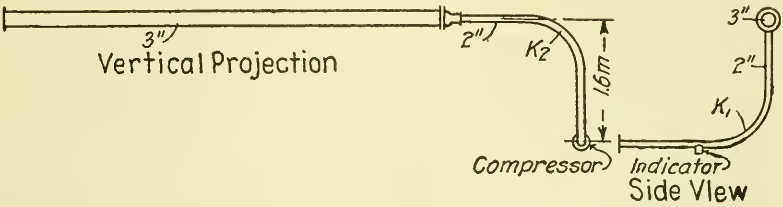

Fig. 5 Suction Piping (Arrangement for Test)

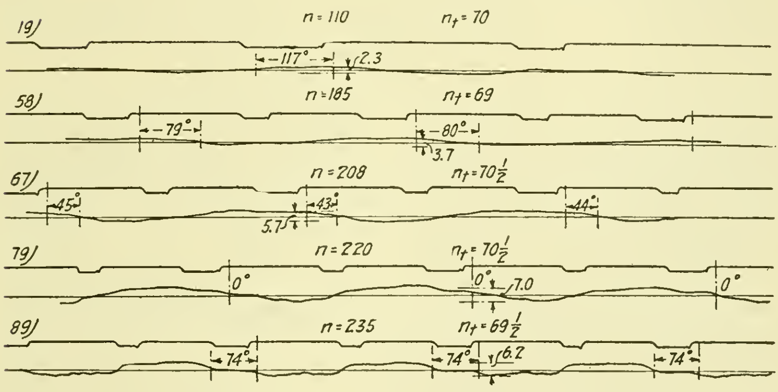

Fig. 6 Pressure-Speed Variation in the Pipino of a Compressor

represented as a converging series of superimposed simple sine waves of increasing frequency, and the resonance can so strengthen each of these waves as to make it predominant or even acting to the exclusion of all others. Friction and inertia dampen the amplitude of vibration of single waves in the case of resonance as well as otherwise, their action being directly proportional to the frequency. Dampening produces also a phase displacement which in case of resonance leads to a lag of a quarter period. The amplitude of single waves is proportional to the compressor stroke and

speed in revolutions. The following equations have been derived for the critical number of revolutions n of the compressor or gas engine (i. e. number of revolutions at which resonance is likely to occur):

For a compressor: $m \frac{n}{60} = (2k+1)\frac{a}{4l}$

For a gas engine: $m \frac{n}{120} = (2k+1)\frac{a}{4l}$

Where l is the length of the suction piping, a velocity of sound, k zero, or some integer, and m the number of oscillations of a single wave during one rotation of the crank. For m the following values are given:

For a single-stage compressor: 1, 2, 4, 6, etc.

For a double-stage compressor: 2, 4, 6, etc.

For a single-acting four-stroke cycle engine: 1, 2, 3, 4, 5, etc.

For a double-acting four-stroke cycle engine: 1, 3, 4, 5, etc.

In a double-acting compressor the resonance of each single wave produces rise of pressure at the end of the suction stroke, while in a single-acting compressor the single waves with frequency of one cycle produce rise of pressure only at the critical number of revolutions, and all other waves at resonance. Air pressure variations are especially to be avoided in the case of gas engines.

The article contains a detailed description of the arrangement of tests for the accuracy of the above formulae. Fig. 5 shows the suction piping, 26 m (83 ft.) long, while Fig. 6 shows the pressure variations, which in the case of a single-acting compressor may be represented by

$$-A_1 \cos wt - A_2 \sin 2wt - A_4 \sin 4wt - A_6 \sin 6wt - \ldots\ldots$$

where A is constant, w is the angle velocity of the crank, and t the time. The resonance produces lag in phase of one-quarter period. Opposite each figure are given the actual test data. As to critical velocity the test shows:

Number of Wave	Calculated Velocity	Actual Velocity	Difference
Second	99	110	11
First	198	220	22

In full agreement with theoretical suppositions, there were two oscillations for each revolution of the crank in the second pressure wave, and only one in the first wave. The phase displacement was found to occur just as was expected. At resonance the end of the suction stroke coincided with maximum pressure for the second wave, and with equilibrium pressure in the case of the first wave; the critical number of revolutions according to both the tests and calculations is twice as high for the first wave as for the second. The waves have a regular appearance and have small oscillations only during suction stroke at high speeds, produced by the fluttering of the suction valve.

For complete data of these experiments see *Mitteilungen über Forschungsarbeiten*, Heft 106, p. 27 ff.

A Study of Springs (Étude sur les ressorts, P. Brenier. *Bulletin de la Société de l'Industrie Minérale*, April and May 1912. 103 pp., 28 figs. *tA*). A very interesting theoretical investigation covering the following points: elastic energy

which can be absorbed by a system of solid elastic bodies; flexibility of metal and its strains generally and shearing strains particularly; the application of the former to the study of volute and laminated springs, and the study of laminated springs which can be practically used (the last as an antithesis to the Philipps and Reuleaux equations for the design of laminated springs which, the author claims, are true only for conditions practically never met with in actual design).

Owing to lack of space, only the conclusions, including the main formulae, are given here.

The number of kilogrammeters (=7.216 ft-lb.) absorbed by a kg. of steel under tension or compression stress is equal to $T=\frac{\theta^2}{2E}$, where θ is the stress in kg. per sq. mm. (1 kg. per sq. mm. = 1422 lb. per sq. in.), E coefficient of longitudinal elasticity and T work absorbed per unit volume.

The number of kilogrammeters absorbed per kg. of steel under shearing stress is $T=\frac{\theta^2}{2G}$, where G is the coefficient of rigidity, so that when the stress on the metal is 80 kg. per sq. mm., or say 113,000 lb. per sq. in., the work absorbed by 1 kg. is 51.5 kg-m. or, in American units, the work absorbed per lb. of steel is 167 ft-lb. Only half of this amount may be allowed in case of a volute spring with round spring wires, and only a third in case of laminated springs.

The deflection of a single coil of a volute spring made of round steel wire under a load of 100 kg. (220 lb.) is $f=0.1\frac{D^3}{d^4}$, and the stress under a load P is $t=\frac{8PD}{\pi d^3}$, where D is the mean diameter of the coil, and d the diameter of the wire.

Laminated Springs. A. Study of a given type. L is one-half the length of the developed full-length plate; l one-half the length of the full thickness part of the small plate, or one-half the length of the small plate without staging; n number of plates in spring; q number of plates at the end of spring; b width of plates; h thickness of plates; $2Q$ load applied in the middle of spring; E coefficient of elasticity (20,000 kg. per sq. mm. or 28,500,000 lb. per sq. in.).

Deflection under load $2Q$ is

$$f_{2q}=\frac{1\ 2QL^3}{Enbh^3}C \qquad [1]$$

where C is a coefficient depending on $\frac{l}{L}$ and $\frac{q}{n}$, its value being given by a table in the text. If all the plates are not of the same thickness, the thickness of any one of them is taken for h, and then the value n' for each plate of thickness h' is determined from the formula $h'^3=n'h^3$, and the values for n' for all the plates added together. The same is done to determine q. The values in the table were calculated by means of a slide rule, and are exact only to the second decimal place, which is sufficient considering other approximate values used in the equations, and especially the uncertainty as to the value of E. Formula [1] is based on the assumption that the sum of the moments of inertia of all the plates is a linear function of the distance from the middle of the spring in the interval lL. The article gives a method for determining the deflection when this is not the case.

The stress under the load $2Q$ is

$$t^1=\frac{6QL}{nbh^2}$$

If all the plates are not of the same thickness, the stress in the p plate is

$$t^1=\frac{QLe_p}{2\sum_1^n i_p}$$

where e_p is the thickness of the plate (it is well to take the thickest plate), and $\sum_1^n i_p$ is the sum of the moments of inertia of all the plates.

Maximum shearing stress $=\frac{Qi_1,}{\sum_1^n i_p}$ and is located at the end of the uppermost plate.

Rational Determination of the Elements of a Laminated Spring. Staging corresponding to the k plate is

$$\frac{L}{\sum_1^n i_p\left(\frac{1}{\rho_p}-\frac{1}{\rho}\right)} i_k\left(\frac{1}{\rho_k}-\frac{1}{\rho}\right)$$

where $\frac{1}{\rho_p}$ is the initial bending of the plate, and $\frac{1}{\rho}$ its bending under maximum load. The successive thicknesses of the plates are determined by the formula

$$e_p\left(\frac{1}{\rho_p}-\frac{1}{\rho}\right)=\frac{2t}{E}$$

where t is the maximum testing stress. The maximum stress allowable in actual service is about one-half of that.

Pumps and Hoisting Machinery

A NEW DEVICE FOR RAISING LIQUIDS (*Eine neue Fördereinrichtung für Flüssigkeiten*, O. B. *Prometheus*, June 15, 1912. 2 pp., 4 figs. *d*). Description, based on an article in the French periodical *La Nature*, of a pump designed by the French engineer Bessonet-Favre, and consisting of a closely wound spiral with a chain inside (Fig. 7). When the pump which is, as shown in *B*, arranged in the form of an endless chain, travels through a liquid, the latter, through the action of capillary forces as well as direct adhesion, sticks between the coils of the spiral, and the spiral on one hand and the chain on the other, and is carried away with the chain. Theoretically it can be carried to any height or distance as long as it is not subjected to shocks; practically this arrangement has been used successfully in wells 40 m (131.2 ft.) deep. The amount of the liquid carried away by the chain depends of course primarily on the proper dimensioning of the parts. When the chain reaches the top it is carried at a considerable speed over a circular pulley, and the liquid is thrown off by the action of the centrifugal force. The pump is extremely simple, takes very little room, is easily cleaned, easily handled, and is said to be unaffected by cold. It is stated that with a hand-driven pump 3600 l. (say 950 gal.) of water per hour were raised 11 m. (36 ft.). With a double chain of 40 mm. (1.57 in.) in diameter a woman raised 4000 l. (say 1050 gal.) of water 8 m. (26 ft.) in 1 hour. The article does not give more exact data of tests.

Valveless Pump Bavaria (*Ventillose Pumpe "Bavaria." Der Praktische Maschinen-Konstrukteur*, June 6, 1912. 1/2 p., 3 figs. *d*). Description of the valveless pump Bavaria recently placed on the market by the Molkerei-

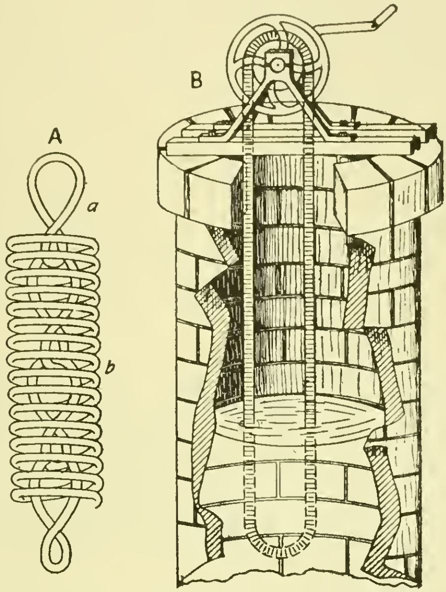

Fig. 7 Bessonet-Favre Chain Pump

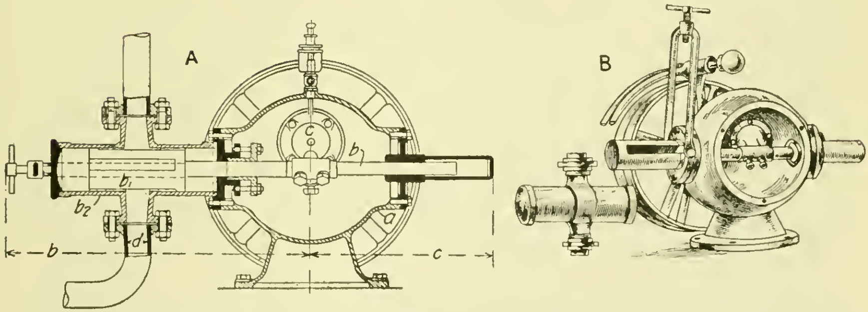

Fig. 8 Valveless Pump Bavaria

machinenfabrik Gebrüder Bayer in Augsburg, Germany. The peculiarity of the construction of this pump consists in that the suction and compression action is due to the rotation of the piston at *b* (Fig. 8 A), while the place of valves is taken by suitably arranged slots in that piston (B). There are

therefore neither slide valves nor poppet valves, but just a cylinder and a piston. This pump is said to be very convenient for handling thick liquids.

Coefficient of Safety of Winding Rope (*Der Sicherheitsfaktor der Schachtförderseile.* Fr. Herbst. *Glückauf*, June 8, 1912. 11 pp., 6 figs. *t*). The author discusses the question of *coefficient of safety of winding ropes* in mines, mainly with a view to the existing German regulations, and attempts to show that under existing conditions a "coefficient" of safety, i. e. something to multiply by the breaking strength values, is unsatisfactory, and that a "margin of safety," such as was proposed by the Transvaal Commission on Cableways of 1906 is preferable. He points out that with the present (German) system of coefficients of safety the weight of the rope increases much faster than the depth of haulage and load, and that probably more accidents are due to this great increase in the weight of the hauling rope than are prevented by the high coefficients of safety. He recommends therefore the introduction of ropes possessing higher breaking strength, and the admission of lower coefficients of safety for very deep haulage.

Twelve-Stages, High-Pressure, "Involute" Pump (*Zwelfstufige Hochdruck-Evolventenpumpe. Der praktische Maschinen-Konstrukteur*, June 6, 1912. 1/2 p., 3 figs. *d*). Very brief description of some constructive details, but not method of working, of a pump said to be constructed on a new principle of which the exposition is promised to appear in one of the following issues of the paper. An abstract will then be given in this *Review*. This entire issue is devoted to description of pumps and blowers.

Steam Engineering

Simplified Steam Engines, M. Lunet System (*Machines à vapeur simplifiées, système M. Lunet*, M. Lunet. *La Technique moderne*, June 15, 1912. 2 pp., 7 figs. *d*). Description of the Lunet steam engines, single acting and double acting, with steam distribution by means of the piston and fixed expansion. The admission of steam on both sides of the piston is effected at the top by means of an extension of the piston rod and from the bottom by a distributor of a similar kind formed in a thickened part of the same piston rod. The steam escapes through a number of orifices placed horizontally in the middle part of the cylinder, and uncovered by the piston a little before it arrives at the upper and lower dead points. The machine has been tested, but the article does not give any precise data of tests, but the author, who is also its inventor, claims for it a very high efficiency.

Steinmüller Water Softening Apparatus (*Épurateur Steinmüller. Electro*, May 1912, 3 pp., 10 figs. *d*). Description of the Steinmüller *water softening apparatus* using the lime and soda process.

Use of Steam Turbines in Mine Haulage Plants (*Die Verwendung der Dampfturbinen bei Hauptschachtförderanlagen*, E. Blau. *Dinglers polytechnisches Journal*, June 22, 1912. 5 pp., 9 figs. *d*). Neither the Ilgner system of haulage plants, nor the plants with direct-current motors and

Leonard system of speed regulation proved to be entirely satisfactory and economic. Brown, Boveri & Co. attempted therefore to introduce the turbine as prime mover for haulage plants. The turbines, besides being simple, cheap, absolutely reliable in operation, economic, and perfectly governable, may, if provided with a special automatic by-pass valve, be arranged so as to be able to take care of peak loads. The article describes two types of such valves, both entirely independent of the turbine governor, as well as two types of turbines, one a combined turbine and the other for power production with part of the steam diverted for heating purposes.

THE NEW CONSTRUCTION OF THE NICLAUSSE BOILER (*Die neue Bauart des Niclausse-Kessels*, F. Geiseler. *Zeits. des Vereines deutscher Ingenieure*, May 18, 1912. 4 pp., 18 figs. *d*). The Niclausse boiler is not new in itself, but the article describes a type lately designed to meet the requirements of the French Navy, and containing many important departures from the older type.

As in other water tube boilers, the most frequent cases of bent and broken tubes occurred among the lower tubes which are most strongly exposed to the action of the fire. To obviate this, the following modifications are introduced in the *new type of the Niclausse boiler:* the vertical headers are divided into two parts (Fig. 9 A) by the partition *a* which cuts off the front feedwater passage at about 1/3 of the height of the header (counting from the bottom up). A second partition *b* is installed in the upper drum; it is an extension of the partitions of the headers, extends far over the normal water level nearly up to the beginning of the steam dome, and divides the upper drum longitudinally into two separate parts, with no connection between. The feedwater is introduced into the front part of the upper drum, falls in the form of a rain in the condensing space *c* where owing to the sudden rise of temperature it begins to get rid of its impurities. It then passes into the front port of the header, flows on until it reaches the partition *a*, and is deflected through the inner circulation tubes into the upper nest of boiler tubes, where it is heated up to the required temperature. It is then partly evaporated and freed of all impurities. The free space between the upper and lower nests of tubes is occupied by the superheater. The water having now a temperature of about 200 deg. cent. (392 deg. fahr.) flows through the back port of the header into the back part of the upper drum (A) whence it passes, through the cavity *d* in the partition *b* (see B and D), into the front port of the back header (B) which is not provided with partitions like the headers in A. In large boilers there is one back header, as in B, for each five headers with partitions as in A. The water now feeds all tubes, upper and lower, in B, flows through e_1 into the horizontal connecting chamber *e*, and thence through e_2 into the lower part of the header of A, feeding the lower tubes which were at the start of the circulation cut off by the partition *a*. The water thus flows through all the tubes of the lower rows, and is very easily evaporated since it already reaches these tubes with a temperature of 200 deg. cent. (392 deg. fahr.). C shows a boiler with five headers, with the back header in the middle, the first section of this unit being reproduced in A.

At the tests of the experimental boiler constructed by the Company in 1910 it was found that the lower tubes were nearly absolutely clean while the tubes of the upper rows were full of deposits, but since only the lower tubes are exposed to the fire, while the upper rows are heated by comparatively cold gases, the problem of keeping the tubes exposed to the greatest heat free of deposits was considered to be solved successfully.

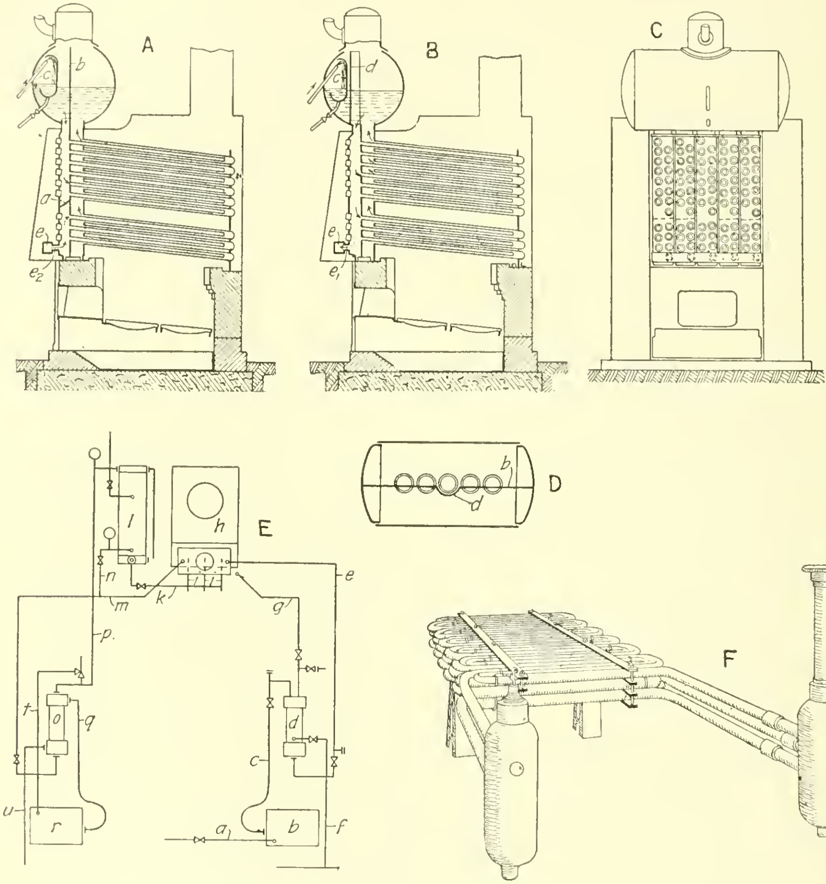

Fig. 9 Niclausse Water Tube Boiler

E shows the arrangement for testing the boilers with oil firing. The purpose of this test was to find out whether the substitution of the back headers for the external downcomers did not interfere with the circulation of water (the tests have shown that it did not), and whether the fire did not destroy the grate too quickly. After a 3½-hour test first with coal, and then oil firing, the boiler was sealed, and next day taken apart: the tubes were found to be clean and straight and the grate in good condition.

F shows the latest design of the Niclausse superheater, such as is inserted between the upper and lower rows of tubes. The holes in the part where there are no tubes are protected by nipples; in some of the boilers with superheaters no holes are made in the middle part of the wrought iron header, so that there are no nipples required. The Niclausse arrangement is claimed to be very convenient because the superheater is protected from the direct action of the fire by the whole lower nest of tubes. Since further it is directly connected with the boiler, and forms practically a single unit with it, it adapts itself automatically to all the fluctuations of service, and is said to make the superheating extremely uniform.

The article describes some auxiliary appliances, such as tube cleaners, brushes, etc.

A Device for Prevention of Flywheel Explosions (*Eine Einrichtung zur Verhütung von Schwungrad-Explosionen, Prometheus*, May 25, 1912. 1½ pp., 3 figs. *d*). Description of a *device for the prevention of bursting of a flywheel* owing to excessive speed, manufactured by C. A. Callm in Halle a.d.S., Germany. It is claimed that this device is entirely independent in its operation of both the flywheel and governor; may be adjusted for any desired maximum speed and tested as to its proper working whenever desired by simple means, and that it may be considered as particularly reliable because it has practically no parts which could get jammed at the wrong time, and because it does not begin to act when the flywheel exceeds the set speed, but is in operation all the time that the engine is running. Fig. 10, A and B, show the longitudinal and cross-sections of the apparatus. In the cylinder of the air pump *a* moves up and down the piston *b* driven by the rod *c* from some reciprocating part of the engine. At the side of cylinder *a* is located the valve chest *d*, with an adjustable opening *e* provided with the bolt *m* at the top, and check valve *f* lower down. The air enters through *e* during the forward stroke of the piston *b*, and escapes in the same way during the backward stroke. For starting, the size of the opening *e* is so adjusted that no more air can enter into the cylinder than can escape during the back stroke without compression. When the piston begins to move faster in accordance with the higher speed of the engine, the opening *e* is no longer sufficient for admitting the air, and the check-valve *f* begins to co-operate with it. But this valve closes during the backward stroke of the cylinder, and since only the opening *e* is left to let the air out, the air is compressed in the cylinder. This air pressure acts on the piston *g* loosely held at the end of the cylinder by a spring so that the piston moves forward and, by means of the setting screw *h* and lever *i* depresses the handle *e* and thereby sets free the pawl *k* connected by a wire cable with a throttle valve in the steam supply main. Usually this valve (or an organ corresponding to it) is kept open, but when the pawl *k* becomes free, the valve automatically closes and cuts off the supply of steam to the engine, thus protecting the flywheel from the danger of bursting. The proper working of the apparatus may be tested simply by closing with a finger the opening *e*, which should produce immediately the displacement of the pawl *k*. The apparatus is said to be very sensitive.

Influence of Cracks on the Stability of Chimneys (*Der Einfluss von Rissen auf die Standsicherheit der Schornsteine, Zeits. für Dampfkessel und Maschinenbetrieb*, June 7 and 21, 1912. 6 pp., 13 figs. *p*). Report of a paper on the influence of cracks on the stability of chimneys read by engineer Pietzsch before the International Association of the Societies for Boiler Inspection at a meeting in Konstanz.

The influence of cracks may be at first investigated in the case of a structure of solid square cross-section, that being the simplest case as far as calculation is concerned. In Fig. 11 (A and B) let D be a side of the square, and let the bending moment due to wind pressure produce an eccentric displacement e of the weight of the chimney G within that cross-

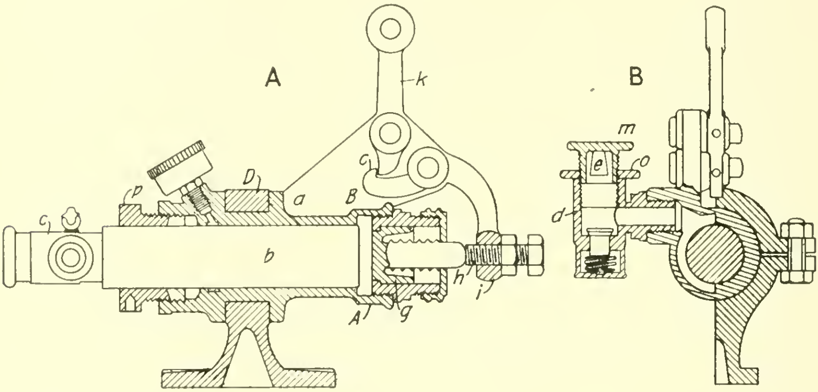

Fig. 10 C. A. Callm Device for Prevention of Flywheel Explosions

section. Then, if $c \leqq \frac{D}{3}$, the stress diagram will take the form of a wedge with an area equal to G, whence:

$$\frac{3cD\,\sigma_{\max}}{2}=G, \text{ and } \sigma_{\max}=\frac{2G}{3cD};\ z=3c$$

Here z is the distance of the most compressed fiber from the neutral axis; c the distance of the center of gravity of the wedge from the most stressed edge; the equation $c+e=\frac{D}{2}$ holds good between e and c.

If we assume that the chimney has been cracked in the middle, we will be near the truth in assuming further that each part will henceforward carry one-half of the wind pressure, so that the bending moment due to the wind pressure G will become $\frac{G}{2}e+\frac{G}{2}e$. If then in the case of a chimney free of cracks $c=\frac{D}{3}$ or $e=\frac{D}{6}$, in a chimney with cracks e must still be equal

to $\frac{D}{6}$, and there remains only $\frac{D}{12}$ for c Fig. 12 (C and D). Since, however, for $c=\frac{D}{3}$, $\sigma_{max}=\frac{2G}{D^2}$ for a chimney free of cracks, it becomes, according to Fig. 11 (C and D) for a chimney with cracks $\left(c=\frac{D}{12}\right)$

$$\sigma_{max}=\frac{\frac{2G}{2}}{3D\frac{D}{12}}=\frac{4G}{D^2}$$

i.e., the maximum edge pressure is twice as great as in the case of a chimney without cracks.

If the crack does not appear in the middle of the cross-section, but eccentrically, the same reasoning holds good; the bending moment due to wind pressure is distributed in proportion to the weight of the parts, with the result that the smaller part may be subjected to infinitely large

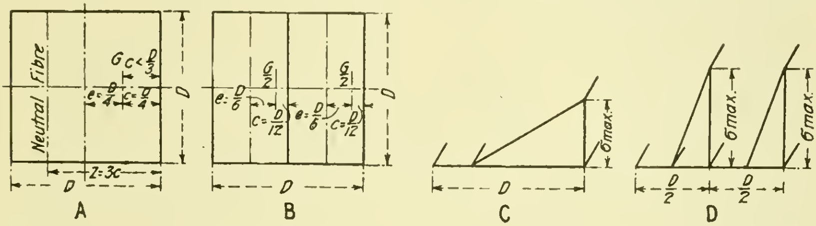

Fig. 11 Distribution of Stresses in a Chimney Cross-Section

stresses even while the eccentricity is comparatively small. Practically, however, while the elastic deformation of the smaller part is proportionately greater, the larger part takes care of the greater part of the bending moment.

In principle all these considerations, though actually deduced for a solid rectangular cross-section, are applicable with some modifications to hollow rectangular and annular cross-sections, the actual work of calculation being, of course, considerably more difficult. One thing, however, is certain, and that is that as far as being injured by cracks, the solid rectangular cross-section is the safest, and that chimneys of actual cross-sections are the more endangered by cracks, the more their cross-section differs from the solid rectangle.

Practically the danger from cracks is somewhat less than would appear from the preceding theoretical considerations, because we never have to do with smooth cracks passing clear through the wall of the chimney, and forming smooth surfaces of rupture offering to each other no material frictional resistance. Actually the construction is such that the surfaces of partition interlock, and offer a very considerable resistance to the displacement of separate parts. In most cases therefore it is enough to put an iron ring on a cracked chimney to make it sufficiently safe.

The author quotes the following among causes of the formation of cracks: (*a*) errors in design (weak construction); (*b*) poor workmanship; hasty construction; unfavorable weather during construction, etc.; (*c*) stresses due to thermal expansion; (*d*) weak foundations; (*e*) destruction of the brickwork bond, from outside by weathering, and from inside by the action of acid gases; (*f*) poor materials; (*g*) explosions of gases in the smoke passages. The second part of the article contains data on the governmental regulations for the erection of chimneys in Austria, Prussia, Saxony and Baden, and a comparison of the Austrian and Prussian types.

Strength of Materials and Materials

Methods of Testing of Materials and Testing Machines Used by the G. Derihon Company (*Materialprüfungsmethoden und Materialprüfungsmaschinen der G. Derihon-Gesellschaft*, E. Valentin. *Der Motorwagen*, May 20, 1912. 5 pp. 36 figs., and 2 sheets of figs. *d*). The G. Derihon Company, at Loncin, Belgium, used to make forgings for factories of weapons, door locks and railway supplies. Later on it began to make forgings for automobiles, and was so swamped with orders from every part of the world that it had to give up all other work, and besides build a second factory in France. The author ascribes the success of the forgings made by the G. Derihon Company to their methods of testing, which gives a hitherto unsurpassed certainty as to the quality of each piece which leaves the factory. Briefly stated, the Derihon system consists in carefully testing the raw material when received from the factory, and again in manufacture. A test piece is taken from each piece out of which an automobile part is forged, carefully tested, and forwarded to the automobile factory together with the part ordered and data sheet of test. Thus, when sending out an order of 28 steering levers, the company accompanies it with a list of 28 tests; this increases the cost per lever by approximately 5 cents, but gives an absolute certainty that the piece will stand as much as it is expected to. The article describes in detail the organization of the testing department, methods and machines used. (Cp. Automobile, July 4, 1912.)

On New Methods of Mechanical Tests of Metals (*Étude sur les nouvelles méthodes d'essais mécaniques des métaux*, *R. Guillery*. *Revue de métallurgie*, June, 1912. 29 pp. 21 figs. *d*). Description of the author's methods and apparatus for testing the hardness, elastic limit and resilience of metals.

The Variations in the Acoustic Properties of Steel with Changes of Temperature (*Variations sonores des aciers en fonction de leur température*, Félix Robin. *Revue de métallurgie*, June, 1912. 56 pp., 45 figs. *eA*.) French translation of the work printed under the same title in the *Carnegie Scholarship Memoirs* of the Iron and Steel Institute, vol. 3, 1911, p. 125 ff.

Strength of Rolled Flanged Joints Against Stripping Off (*Widerstandsfähigkeit von Flanschenverbindungen die durch Einwalzen befestigt sind, gegen Abstreifen*, Professor Baumann. *Zeits. des Bayerischen Revi-*

sions Vereins, Nos. 7 and 8, 1912, through *Zeits für Dampfkessel und Maschinenbetrieb*, June 7, 1912. *e*). Tests have shown that *rolling* is a sufficiently reliable way of fixing *flanged joints*. The resistance against *stripping off* proved to be so great that the joint was stripped off only at a pressure far exceeding the safe limit for the walls of the pipe. The work of fixing the joint must, however, be done well, as ought always to be the case with piping for steam. The tests have not proved the correctness of the usual assertion that *steel flanges* make a stronger unit with the pipe than *wrought iron flanges*, but have indicated the advisability of using appropriate *tough material for flanges*.

On the Use of Metals in the Construction of Steam Turbines (*De l'emploi des métaux dans la construction des turbines à vapeur*, P. Breuil. *La Technique moderne*, June 1. 1912. 5 pp. *e*). Discussion of the problem of *metals used in turbine construction* for blades and labyrinth packing, containing a synopsis of the information found in technical literature, data obtained from manufacturers, and the author's own considerations. Only data referring to Continental European practice will be quoted here.

For *turbine blades* Zoelly uses steel with 5 per cent nickel. Brown-Boveri, who use a large number of stages, with small falls of pressure, and consequently small velocities of steam, use a special bronze with a coefficient of safety of 15 to 20; the blades do not appear to be subject to wear. The German General Electric Company, which manufactures Curtis turbines, makes the blades out of a special bronze or of steel with a high percentage of nickel, with caulking of a softer metal. Rateau, after unsuccessful experimenting with steel with 25 per cent nickel, uses now steel with 5 per cent nickel, while Rey, of Harlé & Cie, prefers steel with 32 per cent nickel.

Inquiries from various French manufacturers of special steel have shown a great diversity of opinion as to the contents of nickel, but it does not appear to the author that any one of them knows just what influence more or less nickel in the steel will have on the behavior of the metal in a turbine blade. Table (1) gives a resumé of the data which the author collected with respect to bronzes. Of these the composition is given only for the "Durana" bronzes manufactured by the Dürener Metallwerke, Düren, Germany, viz.: the first kind 72 per cent copper and 28 per cent pure zinc, and the second kind 85 per cent copper and 15 per cent manganese. The composition of the Monel metal is given as 70 per cent nickel, 29 per cent copper and 1 per cent iron. Like other bronzes, the Monel metal softens considerably at temperatures above 300 deg. cent. (572 deg. fahr.) and has a relatively low elastic limit, but has the advantage of being little subject to corrosion.

The author calls attention to the fact that on the side of the admission of steam the first blades work in high temperatures, with steam at great velocities and dry; the blades further back are subject to lower temperatures and lower velocities of steam, but the steam is wet, and there is besides the friction of mineral particles carried away by the steam. The guide blades are stationary, and are not subject to the action of centrifugal forces like the rotor blades. It appears therefore that different metals

ought to be used for each of these three classes of blades, but in all cases the metal used must possess great resistance to chemical and mechanical corrosion, and be easily machined by ordinary shop processes. As to chemical corrosion of metals by hot steam there are practically no reliable data. From investigations of the action of salt water on metals it would appear that aluminum and manganese bronzes and Monel metal would give good results, but it is quite possible that chemical corrosion is alto-

TABLE 1 STRENGTH OF METALS USED IN TURBINE CONSTRUCTION

Metal	Elastic Limit		Breaking Strength		Elongation Per Cent
	Kg. per Mm.	Lb. per Sq. In.	Kg. per Mm.	Lb. per Sq. In.	
30 per cent nickel steel	50 to 60	71,000 to 86,000	60 to 80	86,000 to 113,000	40 to 30
5 per cent nickel steel:					
(a) annealed	74	105,000	77.5	110,000	36
(b) tempered at 800 deg. cent. (1472 deg. fahr.) and then annealed at 600 deg. cent. (1112 deg. fahr.)	90	128,000	104	158,000	9
Brass (67 per cent copper and 33 per cent zinc)	...	...	31	43,000	55 to 60
Brass (70 per cent copper and 30 per cent zinc)	...	...	28	40,000	50
Aluminum bronze BAT2	...	...	55 to 60	78,000 to 86,000	40 to 45
Rubel bronze:					
290 deg. cent. (554 deg. fahr.)	18	25,600	34.19	49,000	43.5
485 deg. cent. (905 deg. fahr.)	13.7	19,500	20.44	29,000	11.9
Durana:					
100 deg. cent. (212 deg. fahr.)	54	77,000	57	81,000	8.5
300 deg. cent. (572 deg. fahr.)	35	50,000	38	54,000	30
400 deg. cent. (752 deg. fahr.)	12	17,000	20	28,500	75
15 per cent manganese bronze:					
100 deg. cent. (212 deg. fahr.)	58	82,500	63	90,000	10.5
300 deg. cent. (572 deg. fahr.)	52	74,000	58	82,500	21
400 deg. cent. (752 deg. fahr.)	33	47,000	38	54,000	68
Monel metal annealed:					
20 deg. cent. (68 deg. fahr.)	24.1	34,000	55.1	78,000	34.5
300 deg. cent. (572 deg. fahr)	19.4	27,500	30.7	43,500	23.5

gether very slight as compared with physical, and the material used ought to be chosen on the basis of resistance to the latter, with respect to which nickel steel appears to have very high qualities with its breaking strength of 60 kg. (80,000 lb. per sq. in.), elastic limit of 40 kg. (57,000 lb. per sq. in.), hardness 180, and elongation 20 to 22 per cent. It is moreover naturally hard, not brittle, and comparatively cheap. There are no data as to its probable behavior at high temperatures, but having a low percentage of nickel it would probably behave like other steel, and would reach the

minimum of its elastic limit and elongation at about 300 deg. cent. (572 deg. fahr.), without, however, becoming brittle. Wickers Maxim make their turbine blades of laminated bars with a steel core and nickel surface, the nickel layer being only a fraction of a millimeter thick.

Miscellanea

Stone Breaker for Macadam Roads (Concasseur à macadam, P. B. *Portefeuille économique des machines*, June 1912. 2 pp., 4 figs., and 2 plates of drawings. *d*). Description of the J. B. Aillot *stone breaker* for use in building macadam roads, to be driven by a steam locomobile. It does not break the stone exclusively by crushing but also by slugging, for which purpose the jaws of the breaker are provided with staggered slugger knobs of extra hard and tempered steel. These knobs are not all of the same length, but long knobs on one jaw are placed opposite short knobs on the other. As a result, a stone held against two knobs on one side is broken by the pressure in the middle of the stone by the knob on the other jaw. Further all the knobs are so arranged that the stone, after having been broken by one set of knobs, turns around and falls upon a set of knobs just below, where it is struck in a direction normal to the first. The apparatus is claimed to have given very satisfactory service.

Cleaning of Blast Furnace Gases (*L'épuration des gaz de hauts fourneaux*, C. Herwegh. *Société Industrielle de l'Est*, May 1912. 13 pp., 8 figs. *gd*). A general talk on cleaning blast furnace gases, with an illustrated description of the Feld system.

Non-Return Valve for Acetylene Lighting (*Rückschlagsventil für Acetylenbeleuchtung*, A. J. *Zeits. für Elektrotechnik und Maschinenbau*, June 5, 1912. 1/2 p., 2 figs. *d*). The construction of this valve is based on the same principle as that of the Davy safety lamp, viz. that a flame will not ignite a gas through a fine mesh metal screen, unless the screen itself is sufficiently hot. The valve consists of a casing with two fine mesh screens placed in the path of the gas. The screens are either made of double wire cloth, or of single wire cloth, but with the space between the screens filled with asbestos or some similar substance, which both increases the resistance of the valve to backfiring, and helps mechanically to clean the acetylene. The dimensions of the valve have to be generous enough to permit a free flow of gas, notwithstanding the presence of the screens and auxiliary substances.

EMPLOYMENT BULLETIN

The Society considers it a special obligation and pleasant duty to be the medium of securing better positions for its members. The Secretary gives this his personal attention and is most anxious to receive requests both for positions and for men available. Notices are not repeated except upon special request. Copy for the Bulletin must be in hand before the 12th of the month. The list of men available is made up of members of the Society, and these are on file in the Society office, together with names of other good men not members of the Society, who are capable of filling responsible positions. Information will be sent upon application.

POSITIONS AVAILABLE

0183 Young technical graduate with brains, energy and means wanted, to associate himself in an official position with a company recently formed to develop and extend the sale of automatic machines and other labor-saving devices, under extensive and broad patents. The fields to be operated are the mailing departments of all businesses and wherever commodities are handled in sacks. Shop in Philadelphia.

0184 Technical graduate with from two to five years' practical experience, preferably foundry and machine-shop practice, to fill the position of draftsman and assistant sales engineer for a foundry and machine shop in Montana.

0185 Assistant in department of mechanical engineering of university in middle west, to teach machine design, including steam and gas engines and steam turbine design. Some experience in teaching preference, but not the most essential qualification. Apply through Am. Soc. M. E.

0186 Head of department of mechanical engineering in strong and rapidly growing state college, eastern location. Apply through Am. Soc. M. E.

0187 Young engineer, who has specialized in the design and manufacture of stokers. Salary $2,000. Apply through Am. Soc. M. E.

MEN AVAILABLE

463 Position as manager or superintendent with some reliable company; 23 years' experience in heavy, medium, light and interchangeable work, practical and technical; age 43; married; A 1 references; would like to locate in New York, though location is immaterial.

464 Position as chief engineer, 25 years' experience with mines, smelters and mills in erecting and operating all classes of machinery. Twelve years abroad. No objection to location in any foreign country.

465 Member, 20 years' broad experience in industrial lines, capable of

organizing both shop and selling forces to insure economical operation and of marketing products to best advantage, desires to make change.

466 Motor-truck engineer open for position as transportation expert and efficiency man; competent to investigate and report upon delivery system. Eight years' continuous experience in this industry in designing, constructing, testing motor trucks, and writing on truck subjects.

467 Position desired with mechanical trade paper by editor and writer of several years' experience. Sufficient previous practical training and technical education. Knowledge of cuts, printing, makeup and makeready, all phases of publishing work. Competent to bear responsibility and direct others.

468 Five-thousand-dollar man desirous of obtaining a position as chief engineer, consulting engineer or shop manager. Wide experience in steam and hydraulic engineering. Unsurpassed references.

469 Young mechanical engineer, technical graduate, wishes position as instructor in mechanical engineering in some middle western or western university or college. Well qualified to fill position. At present employed.

470 Member who has specialized in power transmission efficiency and is especially well posted in the various means of mechanically transmitting power, desires position with manufacturing concern as mechanical engineer or as assistant to the superintendent in charge of engineering. Would consider connection with a consulting engineer. Executive ability, good systematizer. Now holding good position but wants broader opportunities.

471 Member with extensive experience in engine manufacturing plant, 14 years with last company; thorough practical knowledge of follow-up and cost systems and modern shop practice, seeks connection as superintendent or factory manager. Salary not less than $2700-$4000.

472 Technical graduate, 24 years of age, at present employed as assistant to superintendent in large water gas plant, desires to make a change to concern having an opening along mechanical or sales engineering lines. Opportunity and scope desired.

473 Junior, graduate mechanical engineer with five years' selling experience desires position with company manufacturing steam or gas power plant equipment. Location New York or vicinity.

474 Mechanical engineer, age 34, now engaged, valuation work, machinery shops and all classes of buildings, also railroad properties, will be open for assignment.

475 Junior, technical graduate, age 25, three years' experience in building construction and hydraulic dredging, desires position preferably in power plant design or construction work.

476 Works manager, competent to organize all departments of manufacturing plant along modern lines, long experience on light manufacturing, involving interchangeable parts.

477 Member, now employed, desires change, with wide experience in interchangeable manufacturing, especially engines, machine tools and automobiles, can refer to present and former employers; technical education, four years designing, wide experience with machinery and tools, up-to-date on shop organization, management, production, incentive methods of wage payment, and cost reduction. Age 37, married, $3000.

478 Mechanical and electrical engineer, ten years' experience in the design, construction, operation and management of steam and water power plants for industrial and public service companies, desires permanent position with consulting or contracting engineers in or near New York.

ACCESSIONS TO THE LIBRARY

WITH COMMENTS BY THE LIBRARIAN

This list includes only accessions to the library of this Society. Lists of accessions to the libraries of the A. I. E. E. and A. I. M. E. can be secured on request from Calvin W. Rice, Secretary Am. Soc. M. E.

AMERICAN RAILWAY ASSOCIATION. Proc., May 15, 1912. *New York, 1912.* Gift of the association.

BROWN'S DIRECTORY OF AMERICAN GAS COMPANIES, 1912. *New York, 1912.*

BUILDING AND HEALTH LAWS AFFECTING THE CITY OF NEW YORK. Eagle Library no. 121. *Brooklyn, 1912.*

CHICAGO BOARD OF SUPERVISING ENGINEERS CHICAGO TRACTION. 3d Annual Report. *Chicago, 1911.* Gift of Bion J. Arnold.

COAL CUTTING WITH AN ELECTRIC PUNCHER. Notes from illustrated lecture, J. L. Wagner. Gift of Pneumelectric Machine Company, Syracuse, N. Y.

COLLEGE ENGINEERING NOTEBOOK FOR CLASSES IN TECHNICAL SCHOOLS AND COLLEGES, R. E. Moritz. *Boston, Ginn & Company, 1912.*

This notebook is designed for the use of students in civil, mechanical and electrical engineering. It contains 90 sheets of high-grade rectangular-coördinate paper, five sheets of polar-coördinate paper, and five sheets of logarithmic-coördinate paper. The reverse side of each sheet is ruled horizontally with vertical cross-lines at intervals of 2½ cm.

Additional features of the book are lists of the most important mathematical formulæ from algebra, geometry, trigonometry, analytics, and calculus. These are followed by separate pages of carefully selected formulæ from mechanics, surveying, strength of materials, mechanism, machine design, thermodynamics, electricity and magnetism. The back part of the book contains a four-place table of logarithms, and short tables of natural logarithms, trigonometric functions, exponential functions, squares and square roots, cubes and cube roots, reciprocals, and hyperbolic functions. Finally it contains eight sets of type curves.

DIRECTORY OF ENGINEERS AND POWER PLANTS OF GREATER NEW YORK, 1910. *New York, 1910.*

ELECTRICAL INJURIES, THEIR CAUSATION, PREVENTION AND TREATMENT, Charles A. Lauffer. *New York, John Wiley & Sons, 1912.*

The author is medical director of the relief department in the Westinghouse Electric Company at Pittsburgh. The volume is of convenient size for the pocket. In addition to the matter on treatment of electrical injuries, which is concise, the author has an interesting chapter on the effect of occupations on health. Altogether a very interesting little volume.

ENGINEERING SOCIETY OF WISCONSIN. Proc. 1-2. 1909-1910. Gift of Engineering Society of Wisconsin.

FINANCIAL SIGNIFICANCE TO THE GAS INDUSTRY OF THE MODERN BY-PRODUCT OVEN, Paul Schlicht. Read before the Institution of Gas Engineers, June 1907. Westminster. Gift of the author.

GENERAL CONTRACTORS ASSOCIATION. Bull. vol. 1, 1910. *New York, 1910.*

GESCHICHTE DES VEREINES DEUTSCHER INGENIEURE. Nach hinterlassenen Papieren von Th. Peters. *Berlin, 1912.* Gift of the Society.

GOOD ROADS YEARBOOK. 1912. *Washington, 1912.*

HANDBUCH DER BAUSTATIK. A. F. Zschetzsche. *Dusseldorf, 1912.*

HISTORY OF NEW YORK SHIP YARDS. J. H. Morrison. *New York, 1909.*

JAHRBUCH DER LUFTFAHRT, 1912. vol. 2. *Munchen, 1912.*

THE LOCOMOTIVE. vol. 28. Hartford, 1910-1911. Gift of Professor Hutton.

MARINE STEAM TURBINES. G. Bauer and O. Lasche. Translated from the German by M. G. S. Swallow. *New York, 1911.*

MECHANISCHE TRIEBWERKE UND BREMSEN. Dr. St. Löffler. *Munich, R. Oldenbourg, 1912.*

This small work treats of power transmission from the mathematical standpoint, developing formulæ for belts, gearing, rope drive and brakes. It should be of interest particularly to the automobile engineer.

THE MNEMONIC SYMBOLIZING OF STORES UNDER SCIENTIFIC MANAGEMENT, Howard G. Benedict. *1912.* Gift of the author.

MODERNE AUTOMOBIL SEIN BAU UND BETRIEB SEINE PFLEGE UND REPARATUREN, M. Peter. *Berlin, 1912.*

NEW YORK CITY BOARD OF WATER SUPPLY. Contract 101. *New York, 1912.*

NEW YORK STATE ENGINEER AND SURVEYOR. Annual Report 1910, 1911, vol. 1. *Albany, 1911-1912.* Gift of State Engineer and Surveyor.

NOTES ON HEATING AND VENTILATION, J. R. Allen. ed. 3. *Chicago, 1911.*

PRINCIPES D'ORGANISATION SCIENTIFIQUE DES USINES, F. W. Taylor. *Paris.* Gift of the author.

DIE SAUGGASANLAGEN IHRE ENTWICKLUNG, BAUART, WARTUNG UND PRÜFUNG. G. Lieckfeld. *Munchen, 1909.*

STOHMANNS HANDBUCH DER ZUCKERFABRIKATION, A. Schander. ed. 5. *Berlin, 1912.*

WORKMEN'S COMPENSATION FOR ACCIDENTS, F. E. Law. *New York, 1912.* Gift of Fidelity and Casualty Company of New York.

UNITED ENGINEERING SOCIETY

EARTHWORK DIAGRAMS. C. A. James. *White Haven, Pa., 1912.* Gift of the author.

HOW TO PLAN A LIBRARY BUILDING FOR LIBRARY WORK. C. C. Soule. *Boston, 1912.*

NEBRASKA STATE RAILWAY COMMISSION. 4th Annual Report to the Governor. 1911. *Omaha, 1911.* Gift of the commission.

REPORT ON REVALUATION OF RAILROADS AND CANALS, NEW JERSEY, 1911. *Trenton, 1912.* Gift of Chas. Hansel.

SVENSKT PORTRÄTTGALLERI ANDRA SERIEN. I. Svenska Teknologföreningen 1911. *Stockholm, 1911.* Gift of Svenska Teknologföreningen.

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LINDLEY, W. H. Anlagen zu dem generellen Projekt der Kanalisation der Stadt Würzburg.

———Barmen-Elberfeld Entwässerung. Denkschrift über die Klärung der Abwässer, vom 14 September 1901.

——— ———Erläuterungs-Bericht zum Projekt einer Klärungsanlage für die Abwässer von Barmen-Elberfeld auf dem Gute Buchenhofen. 1902

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———Entwässerung der Stadt Homburg v. d. Höhe. *Frankfurt a. M., 1886.*

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———Lodz. Entwässerung. Generelles Projekt. Erläuterungs bericht nebst 5 und 8 anlagen. October 1909.

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Un den verehrlichen Stadtrath der Grossherzoglich Badischen Hauptstadt. *Frankfurt a. M., 1890.*

EXCHANGES

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COURS D'ELECTROTECHNIQUE DE L'ECOLE D'APPLICATION DU GÉNIE MARITIME. Electrotechnique speciale aux Bords. Book 3. 1911-1912.

COURS DE METALLURGIE DU GENIE MARITIME. vol. 1-2. 1910-1912.

U. S. PATENT OFFICE. ANNUAL REPORT OF THE COMMISSIONER. 1911. *Washington, 1912.*

TRADE CATALOGUES

BEST MFG. CO., *Pittsburgh, Pa.* Catalogue and handbook of piping material for steam, air, hydraulic, high pressure systems. 395 pp.

BRISTOL CO., *Waterbury, Conn.* Recording instruments for pressure, temperature, electricity, speed, time, etc., 64 pp.

CHICAGO PNEUMATIC TOOL CO., *Chicago, Ill.* The anatomy of the Little Giant Commercial Car. 24 pp.

GREENE, TWEED & CO., *New York.* Latest improved Rochester automatic Lubricators. 48 pp.

HART & COOLEY CO., *New Britain, Conn.* Wrought steel ventilators and registers. 48 pp.

HESS-BRIGHT MFG. CO., *Philadelphia, Pa.* Ball bearing hangers. 32 pp.

INGERSOLL-RAND CO., *New York.* "Radialaxe" air driven coal cutters. 20 pp.

MANHATTAN DRILLING CO., *New York.* Dobbins core drills. 20 pp.

NELSON VALVE CO., *Philadelphia, Pa.* Nelson steel valves and fittings. 62 pp.

PNEUMELECTRIC MACHINE CO., *Syracuse, N. Y.* Electric rock drills, 7 pp.

W. B. SCAIFE & SONS, *Pittsburgh, Pa.* Range boilers and high pressure tanks, 35 pp.; Scaife water filters. 32 pp.

SPRINGFIELD BOILER & MFG. CO., *Springfield, Ill.* Boilers and boiler supply material. 47 pp.

STANDARD MACHINERY CO., *Providence, R. I.* Presses, drop hammers, swaging machinery. 31 pp.

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Multi-stop and Double Turners

FIG. 1 illustrates the advantage of the *double stop* for each position of the turret, and the *double* adjustment of each turner. This piece has six finished diameters and six shoulders; and is turned by only three turners, which occupy only three positions on the turret. This not only leaves the remaining positions free for other tools, but it saves the operator the time and energy required to run the turret slide back each time.

All this is obtained without complication, and without introducing any features that are annoying when not in use.

In addition to the double stop for each of the six positions of the turret, we have an extra stop, consisting of a pin which may be dropped into any one of the six holes at the rear of the turret slide. This makes it possible to borrow five extra stops for any one of the tools, and gives to this tool seven length or shoulder stops, and leaves one stop for each of the remaining tools.

FIG. I

The illustrations, Figs. 2 and 3, give examples of what one tool can do in this machine on chuck work, when we take advantage of the seven length stops and the seven shoulder stops of the cross-feed head.

Of course, in general practice three or four stops for one tool are all that will be needed, but since the modern cutting steels have greater durability, there is nothing lost by giving each tool all the work it can do.

Outer face and all shoulders and diameters accurately finished to independent stops by one tool. When roughing and finishing cuts are required, the roughing tool can be set near enough to use the same stops that are accurately set for the finishing tool. When an extra tool is used to give a roughing cut it is set as indicated by dotted lines in Figs. 2 and 3.

We find it difficult to illustrate all of the classes of work that can be turned out by this machine, but a little thought will suggest

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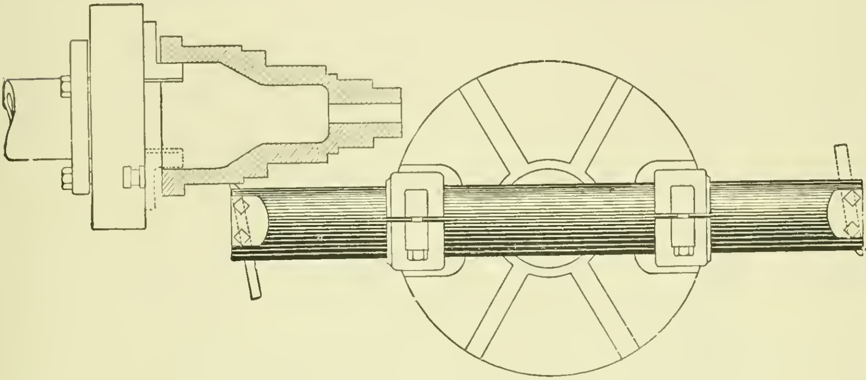


FIG. 2

many forms that may be readily handled in bar and chucking work, both steel and iron, on account of the many provisions for bringing both turret and cross slide up to fixed stops; either by power feed or by hand.

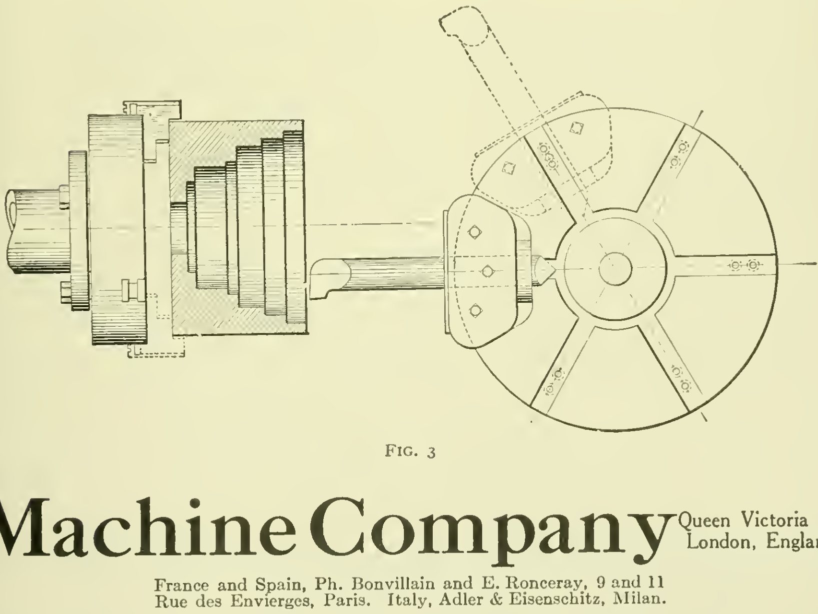
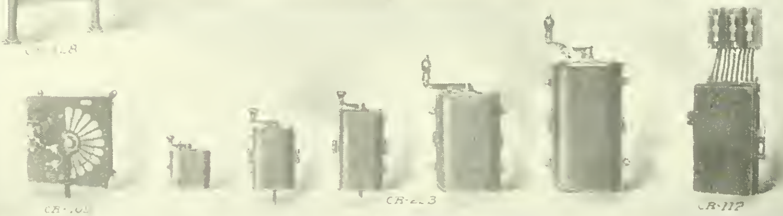


FIG. 3


CR 121
CR-114
CR-205
CR-163


CR-153
CR-116
CR 223
CR 126



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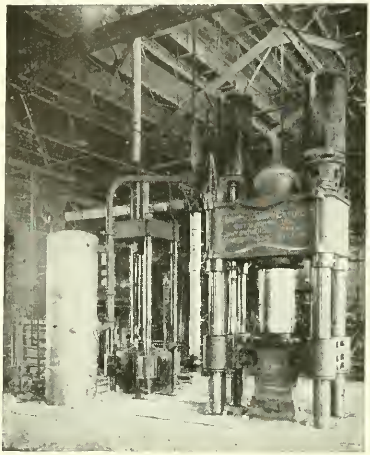

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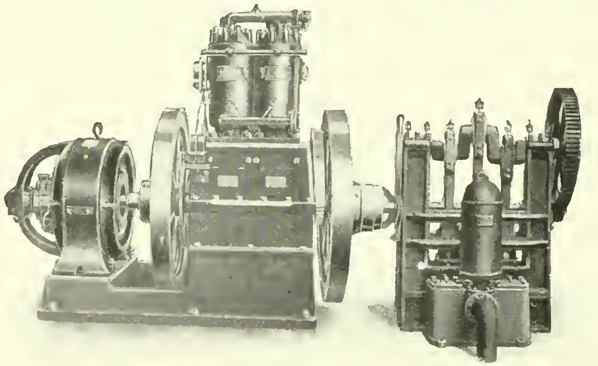

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